A SPECIAL REPORT

How to Specify

A thorough review for the specification writer on three types of equipment... process heaters, tanks and pumps. p. 86

OIL, GAS AND PETROCHEMICAL PROCESSING

Petroleum Refiner

AUGUST
1959

BUILDING BLOCK

Propylene—Olefin to Watch 107

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For a "Quick Look" at this issue, turn the page . . .

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Volume 38, No. 8 August 1959

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Petroleum Refiner

OIL, GAS AND PETROCHEMICAL PROCESSING

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SPECIAL REPORT: HOW TO SPECIFY

☐ **How to Specify Process Heaters . . .** Even though you may not qualify as an expert heater designer, this guide will enable you to raise questions for the designer and assure yourself that all essential elements have been considered. This article tells what kind of information you need and includes a form which will be useful in summarizing heater design basis. To brush up on specifying heaters, turn to Page 86.

☐ **How To Specify Tanks . . .** What do the bidders need to know? What standards should your inspectors apply? Should you call for a corrosion allowance? How much X-ray? What kind of materials do you need? You'll find the answers to these questions in regard to storage tank specifications by turning to Page 99.

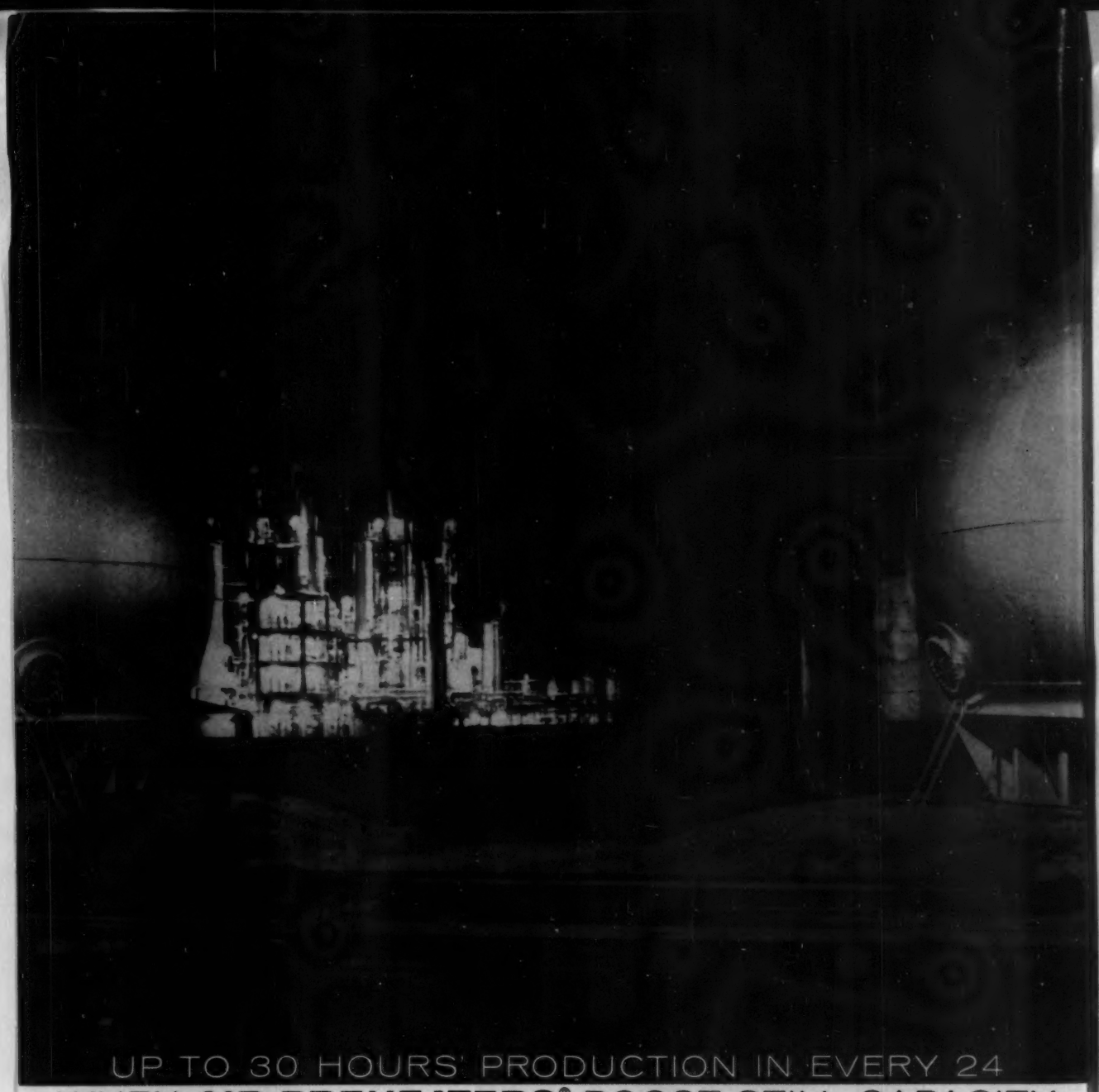
☐ **How To Specify Pumps . . .** Since pumps are becoming more and more standardized, why not do the same with your pump specifications? A standard specification form and vendor's data sheet eliminates errors, helps you in bid evaluation and keeps your specification time at a minimum. For details on how to set up your standard forms, turn to Page 105.

☐ **Watch Propylene's Steady Growth . . .** This country cousin to ethylene, while not a slumbering giant, does have a bright, solid future. For data on production, utilization and some insight into its future, turn to Page 107.

☐ **Trouble Shoot With Vibration Analysis . . .** High speed rotating machines in refineries are presenting tough vibration problems in maintenance. However, here are five case histories which clearly show how you can solve many of these problems by using a vibration analyzer. Learn how to use one in your plant. Turn to Page 115.

☐ **Applied Hydrocarbon Thermodynamics . . . Part 12: Equilibrium Flash Vaporization Correlations for Petroleum Fractions . . .** Since you never have the time nor the money to run experimental vapor-liquid phase equilibria data for complex mixtures, you

Please Turn Page ➡



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A Quick Look at This Issue . . .

would like to have some empirical method of predicting these data. Well, here is Edmister again (this time with Dr. Keith Okamoto) with exactly this sort of a correlation for you. This is an improved method over those you have used from previous correlations. You'll agree after you've tried the method shown on **Page 117.**

☐ **Operator's Handbook for Gasoline Plants . . .** The second part to this series on natural gasoline operations and equipment tells about the piping and valves which are important to the plant. It's written so both the new and experienced operator can understand the why of plant operations. Turn to **Page 130.**

☐ **Get Better Curves From Your Data . . .** Use the method of least squares to get better correlations from your data. Here you'll find examples of how to fit data with linear or quadratic curves, and also a method of error analysis which will tell you how good the curves are for making predictions. You will want to review this powerful tool for systematic appraisal of data, so turn to **Page 135.**

☐ **Use These Tricks to Speed-Up Answers . . .** A trial and error calculation can be long and tedious if there is no knowledge of the magnitude of the final answer. An analysis of the general relations can speed-up the answer by giving an informed guess for the first trial. See how this system works on a hydrodesulfurizer and absorber problem. Turn to **Page 143.**

☐ **Sharpen Your Learning Habits . . .** How to Remember: Part 1 . . . It only stands to reason that you can't forget something if you never really learned it in the first place. Therefore, the first step to improving your memory is to learn better. Here are some learning techniques which will enable you to develop your power of retention--and remembering. You'll want to clip this one and refer to it from time to time, so turn now to **Page 175.**

☐ **How to Present a Construction Estimate . . .** Few things are more discouraging than to have your estimate cut up by a misunderstanding management. It's probably your fault though, so take this sound advice which you'll find plenty helpful next time you face "Mahogany Row." Turn now to **Page 185.**

☐ **Why the Courts Said 'No' to Commerce Oil . . .** Here is the full story on the court ruling which banned Commerce Oil from building its planned Rhode Island refinery on the grounds that it would be a nuisance. Turn to **Page 190.**

Popular Petroleum Refiner reprints available . . .

These reprints of PETROLEUM REFINER articles have enjoyed an excellent demand from men in the oil, gas and petrochemicals processing industry. They are available at $1.00 each.

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Photo shows Feralay Condulet conduit fitting after several years exposure to hydrochloric acid. Note extreme deterioration of conduit.

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RESISTS acids, alkalis, salts

RESISTS varying concentrations and temperatures of corrosive liquids, vapors, gases, dusts

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PIPE LINE INDUSTRY and The PIPE LINE CATALOG for the oil and gas pipe line industry.

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Coming Up—

WE DERIVE a great deal of satisfaction from putting together one of our specials such as the Process Developments Issue due next month. If for no other reason, it gives us a reason to appraise the overall refining industry. We study intensively technical material published, we ask our industrial friends what is missing, we make individual visits to licensors, construction-engineers, and refiners throughout the nation to find out what they are thinking and doing. Then we compile the results in a format attractive and convenient for readers.

The upcoming issue will include at least 12 valuable feature articles giving detailed descriptions of important processes and new refining techniques. Recent operating data, of course, will be included.

One super feature of this issue: Dr. Edward G. Scheibel presents a completely rigorous, but simple-to-use method for stagewise calculations in multicomponent fractional liquid extraction. This *and* a 24-page review of correlations and predictions of liquid distribution data *plus* a new method for developing a thermodynamically consistent correlation of liquid distribution data will make this the most important article in your extraction file.

So be on the outlook for the Process Developments Issue which, we would remind you, serves as a logical supplement to PR's authoritative Process Handbook which is published in alternate years in September.

No. 1 Still No. 1

AS OIL'S actual centennial date approaches, more and more attention is being given by magazines and newspapers to the event. PETROLEUM REFINER last January more or less kicked off the year with its Centennial Issue, a carefully planned volume that one of these days likely will become a collector's item.

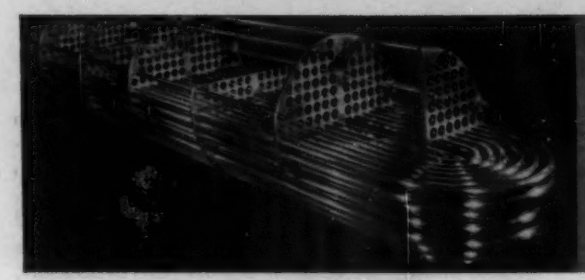
We were proud then of our January issue, that one that carried the attractive insigne that proclaimed oil's 100th birthday, and our pride has not diminished as other publications have come forward with their effort. Oil has a wonderful history and a brilliant future and nowhere have these—especially the look ahead—been handled better in a single volume than our own dated January '59.

Buys An Idea Plus

WE HADN'T FIGURED it exactly that way before, but doesn't it look like good thinking?

A subscriber at a big East Coast refinery told one of our editors recently that he makes an effort to read each month not only PR's editorial content but the ad pages in addition. "PR's subscription rate is so low and its editorial section is so fat that one doesn't have to be a publisher to realize that the advertiser is paying the bill," he said in effect. "And if they think it smart to go along with that idea in describing their products, then I'll 'buy' to the extent of reading what they have to say."

The clincher is that, "I have purchased a number of items for the refinery after reading about them in PR ads."



CONDENSER AND HEAT EXCHANGER CLINIC

Edited by David S. Hibbard, Metallurgical Engineer
The American Brass Company, Buffalo 5, New York

New tube mill equipment gives designer of heat-transfer units freer hand in meeting new trends

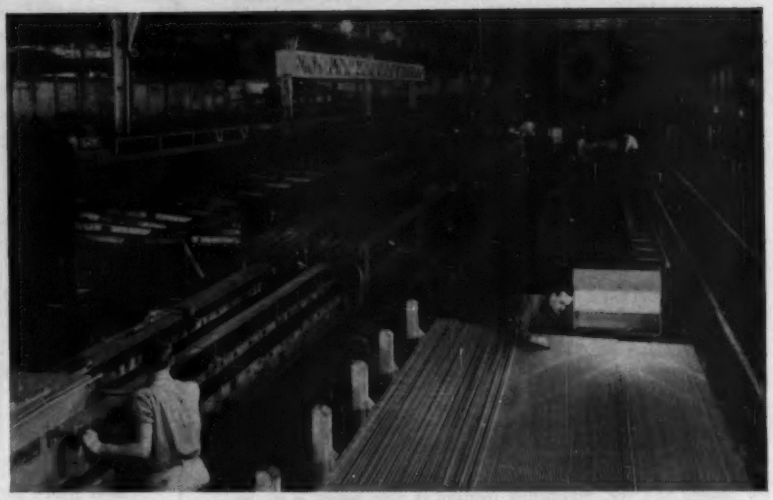
With the installation of new production and testing equipment, The American Brass Company now offers the most complete service available to users of condenser and heat exchanger tubes.

Long lengths. To gain advantages in construction, processing, or installation, designers can lengthen equipment considerably. Tubes can now be drawn up to 100 feet. Most of the longer tubes are required as U-bends, but in some instances may be shipped as straight lengths.

U-bends. Tubes from ⅜" O.D. to 1½" O.D. with wall thicknesses from .049" (18BWG) to .134" (10BWG) can be bent on a radius of from 1¼ times the tube O.D. to 30".

Dual Gage. Where high temperatures and pressures are involved, it may be desirable to thicken the tube wall in the area of short-radius bends on U-bend tubes. Walls are thickened one Stubs' Gage No. to compensate for thinning of metal in the bending.

Thickened Tube Ends. To compensate for thinning by rolling or by impingement corrosion caused by high velocities, tubes may be supplied with the wall thickened at one end one or more Stubs' Gage Nos. The extra thickness may be on the outside or inside of the tube as required.



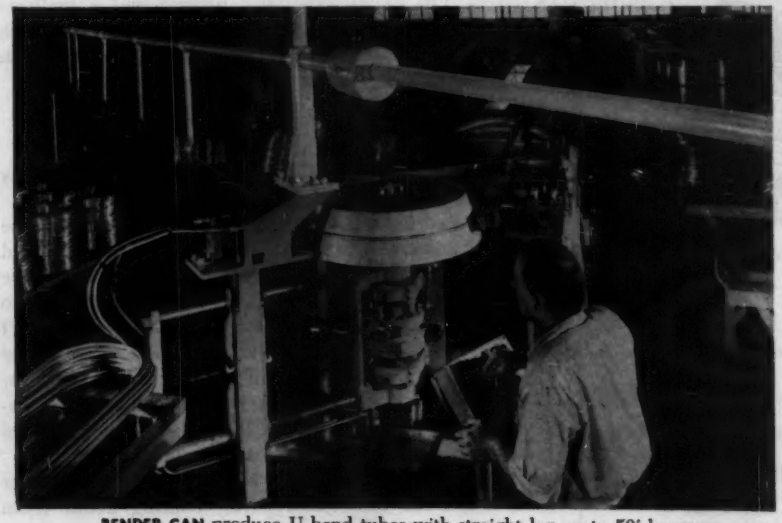
GENERAL VIEW of new American Brass Company equipment which can draw copper and copper alloy tubes in lengths up to 100 feet.

Relieving Stresses. All U-bend tubes, other than copper, are annealed at the bend area after bending, to eliminate the hazard of stress-corrosion cracking which might occur in service due to stresses that may exist as a result of the bending.

Testing. U-bends are tested hydrostatically at ASTM-Specification pressures —or at ASME Code pressures up to 6000 psi on request, if the tube size will stand it. Electronic inspection with eddy-current equipment is available also, when required.

Shipping. U-bend tubes are shipped packed for ease in handling and storage.

Technical Assistance. For more detailed information on extra-long tubes, U-bend, Dual-gage, or Duplex tubes to meet special problems, address: The American Brass Company, Buffalo Division, Buffalo 5, New York. In Canada: Anaconda American Brass Limited, New Toronto, Ont. 8867 Rev.



BENDER CAN produce U-bend tubes with straight leg up to 50' long.

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Quick Look at Industry...

Oil Management Getting Tougher . . .

By now it's clear higher wages and fringe benefits are only part of the story behind the steel strike—real issue at hand is who will run the big mills . . . management or labor? Faced with the same showdown: Indiana Standard and subsidiary, American Oil.

Already on strike are Amoco's big 145,000-bpd plant at Texas City and 38,000-bpd refinery at El Dorado, Ark. Work stoppage has also idled Indiana Standard's 74,000-bpd Sugar Creek, Mo. plant and its giant 209,000-bpd refinery at Whiting.

Specifically, what are the issues? Main contention is union insistence of voice in making job assignments and determining number of men assigned each function. Management contends right to organize work force and utilize employes to best advantage cannot be yielded to union.

Sugar Creek issues are essentially the same, but tempers are hotter. President of striking local called company stand, "most blatant and barefaced union-breaking attempt to appear on the American scene since the notorious bloodstained days of the first Pullman strike and the Ludlow massacre." On top of this, company had to get court injunction barring wives of strikers from blocking railway and tank car shipments at plant.

Meanwhile, supervisors of strike-bound plants have put some units back on stream. Texas City now running about 35,000 bpd while Sugar Creek processes 20,000 barrels daily.

Operation "Plowshare" Budget Slashed 25 Percent . . .

House Appropriations Committee isn't convinced research and development of industrial uses for underground atomic explosions should be put on "crash" basis. Result: budget for '60 cut from $8 million to $6 million. Proposed projects include use of atomic energy to recover oil from shale and tar sands, excavate harbors and canals, generate power.

AEC assured Congress "Plowshare" blasts won't contaminate—will use relatively clean devices to reduce radioactivity to safe level.

More Petrochemical Upgrading . . .

Amoco Chemicals' new polystyrene plant at Joliet, Ill., to use process developed by Indiana Standard—another example of refiners going that extra step to convert surplus aromatics into more valuable material.

Crown Central—Likely to Fold? . . .

Crown Central president S. K. Waters sounded this warning to Imports Appeals Board: if his company losses continue in same magnitude as through Dec. 31, he'll recommend company liquidation.

Quick Look Around the World . . .

Japanese petrochemical production for first half '59 up 44% over like period in '58. . . API makes official recommendation for oil change every 30 days in winter and every 60 days in summer—but never to exceed 2,000 miles . . . not one single new piston-powered plane

ordered for any major airline in the world . . . U. S. Market for asphalt and asphalt products increased by 11% in 1958 . . . Aramco now offering natural gas for sale in Saudi Arabia.

Texaco-Paragon Merger Set . . .

Paragon Oil now merged with the giant Texaco, Inc., but will continue to operate as separate entity under same corporate name. Just last month Texaco and Superior Oil announced joining of forces in what looks like one of the biggest mergers to hit oil scene in long time.

Another change in ownership sees Midland Cooperatives agreeing to sell its 10% interest in 30,000-bpd National Coop. Refinery, McPherson, Kan. to Iowa Farm Supply, Des Moines.

Synthetic Fibers Spur Southern Growth . . .

Look for petrochemical synthetic fiber expansion to continue on greater scale—especially on Texas Gulf. Expert says by 1975, more than 87% of new petrochemical plants for synthetic fiber intermediates will be in Texas Gulf area. Roughly this means about $245 million in new plants —at the same time West Virginia area will get about $40 million worth.

Panning the Building Scene . . .

Conoco to add 11,000-bpd cat reformer at Lake Charles refinery . . . Esso's German affiliate, Esso A.G. to build 60,000-85,000-bpd plant in Karlsruhe, W. Germany . . . Aramco to put up near Ras Tanura refinery, first plant in world to make LPG for tanker shipment (more items on page 158).

Octanes Still on the Rise . . .

Latest BuMines survey shows national octane average still rising. Total of 5,777 samples from 100 different companies last winter saw regular gasoline hit average of 90.6; premium, 98.9; and super-premium 101.8 (full story on page 207).

Latest Ethyl survey for July shows premium averaged 99.1 F-1—unchanged from June. Regular inched up 0.1 octane to give July average of 92.0 F-1.

New Tool for Ignition Studies . . .

Surface ignition studies on car engines under actual service conditions now possible with new pressure-sensitive spark plug. Likely results: better fuels; improved auto engines.

Reds Lag in Lube Fields . . .

Soviets not ahead in field of lubricants says recent U.S. study of published Russian literature. Red-nation researchers apparently still concentrating on areas already fairly well defined by U.S. scientists.

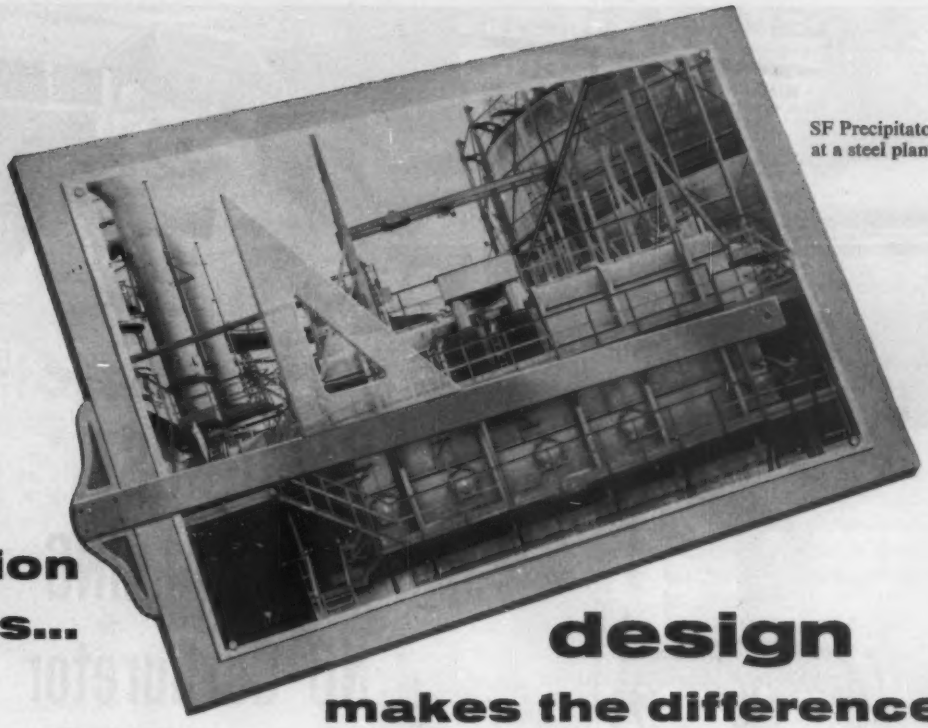
Sulfur Dioxide Divorced from Smog . . .

Proposed regulation to limit sulfur content of fuel oil in San Francisco Bay area criticized by refinery representatives. Howard Vesper, SoCal-Western president, reports no conclusive evidence that sulfur dioxide has anything to do with smog. Thus, proposed limitations on sulfur would unnecessarily restrict available fuel oil.

What's the Supply-Demand Picture? . . .

Refinery runs averaged about 8.04 million barrels daily during first half '59, but were 150,000-160,000 bpd too high. Result: mid-year gasoline stocks about 25 million barrels above desired level—in spite of a 6.5% increase in gasoline demand.

Look for better balance in 3rd and 4th quarters—reduced refinery runs and strikes well help slash inventories.



SF Precipitator at a steel plant.

In Dust Collection Systems... design makes the difference

Higher efficiency of Buell 'SF' Electric Precipitators is the result of exclusive engineering features. For example, Buell's *Spiralectrodes* emit 50% to 100% more electrons than other types . . . and *maintain* their efficiency. Positive gas flow control through adjustable baffles prevents scouring and eddying. And Buell's Unique Continuous Cycle Rapping practically eliminates "puffing".

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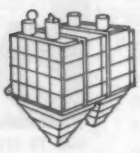
Lower installation cost of Buell's time-proved simplified design makes erection faster and easier. Spiralectrodes, for example, are self-tensioning, require no weights. Flexibility of power supply means easier installation, operating safety.



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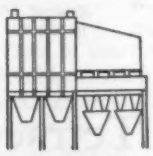
Lower maintenance cost is the result of many details of superior design. And sectionalized design permits shutting down part of a unit without interrupting service in the rest of the unit.

Get full information: write for a copy of "Buell SF Electric Precipitators", a 22-page booklet. Write to Dept. 21-H, Buell Engineering Co., Inc., 123 William Street, New York 38, N. Y.



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PREVENTS STALLING due to carburetor icing. Gasolines treated with sufficient RP-2 give stall-free operation at minimum additive cost.

KEEPS CARBURETORS CLEAN. RP-2 adds a detergent action to your gasolines which not only keeps new carburetors clean, but gradually cleans the throttle plate and throat of carburetors which are already dirty.

CONTROLS RUST. RP-2 forms a barrier between metal and moisture. This blocks rust formation throughout the entire fuel system from gas tank to carburetor. Stops rust during storage at refinery and at service stations, too.

CONTAINS PHOSPHORUS. Consequently, you can take a "phosphorus credit" if you're already using phosphorus for control of surface ignition.

For more information on this additive and a complete program for marketing its advantages in your gasolines, call in your Du Pont representative or write Petroleum Chemicals Division, E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Delaware.

HOW TO SELL GASOLINE WITH RP-2—This sample advertising kit shows how you can use RP-2 to create new market excitement for your brand of gasoline. See your Du Pont representative or write for the kit.

DU PONT

Better Things for Better Living . . . *through Chemistry*

Tetraethyl Lead
and other
Petroleum Additives

Memo to a Liar and a Cheat!

WHAT WOULD BE your reaction if someone—probably a complete stranger—came up and called you a liar, a cheat, a chronic lawbreaker and several other unflattering names.

Well, first off, you probably would be somewhat stunned because of the ridiculousness of such charges. Because after all, everyone knows you're a fine neighbor and a good, law abiding citizen. Next, you would probably start to get pretty mad at a guy who would even think such things about you.

Well, get ready for a first class mad. Because you've been called a liar, and a cheat, and a chronic lawbreaker, and many other vicious names. You have been called these things because you are connected with oil, and these are the charges which have been hurled at the American oil industry. The charges are repugnant to you because of their absurdity, but they are believed by a great many people just because they hear only one side of the story. Such charges tear into the "unscrupulous and unprincipled" oil companies for their supposed attempts at bribing public officials, buying legislative votes, and price-fixing to swindle the consuming public.

Here's the Important WHY

This is an editorial on oil industry public relations—and please for your own and for the industry's sake don't shrug it off with a, "Here we go again!" We know you've heard a great deal about this subject—in fact we're the first to admit that it's a favorite topic of ours.

But apparently some on-the-carpet talks are needed because indications are that we haven't made too much progress along public relations lines during the past several years. People are talking about us—you and me—and we—you and I—had better arm ourselves with the facts so that we can talk back.

Here we would convince you that an all-out effort is needed, and commencing immediately, to counteract the slanders that are being piled up against our industry. If we leave that effort to a group of the big companies or a group of articulate individuals or even to the API Committee on Public Affairs, then we're lost.

You must be ready—and anxious—to do YOUR part.

A Senator Speaks. For those of you who think it's just a few irresponsible individuals who are making these charges, let us cite what Senator Wayne Morris (D-Ore.) said about you one day on the Senate floor. Spouted the Honorable Senator, "Let us not kid ourselves. Does anyone think for a moment the oil companies are not playing an exceedingly strong part in American politics? It is well known that oil interests not only try to influence elections, but they try to buy elections. I think it is about time we stand up against the oil companies and make clear to them that they ought to go back to their businesses and stop their practices of dirty and corrupt political tactics. Too many of these oil companies have their hands dripping, in my opinion, with political corruption in the field of American politics . . ."

And supplementing this rabble-rousing tirade, Senator Proxmire (D-Wis.) replied, "I thank the Senator from Oregon. He has hit the issue on the nose."

Now, these are not what most people would call irresponsible individuals just talking through their hats. These are United States Senators—the men who make the laws of our land. Is it any wonder, therefore, that a large percentage of the American populace thinks ill of us after they hear such words from Honorable men of such high position?

Now . . . you may say you've heard, and possibly read, all of these accusations, but that they apply to the entire oil industry—not just to you as an individual. But let's pause here to remember that there is no such thing as an industry as a whole without its individual members. Even with the advanced state of automation we have reached today, it still takes people to run our great oil, gas and petrochemical industry. And, as one of the people, you are one of those "bribing, vote-buying swindling" individuals.

Frank M. Porter, president of the API, emphasized that point in a recent statement:

"If the oil industry is engaged in stealing from the American public and the American government, as has been alleged, then every person engaged in that industry is an accomplice in the crime. And that same philosophy holds true right down the line. In other words, if the oil industry is immoral, then you

Scrub Carbon Dioxide from Process Gases

with SOLVAY POTASSIUM CARBONATE

If you're scrubbing gas from a natural gas stream, for ammonia synthesis or in some other petrochemical application, you may be able to do the job more efficiently, for less money, via the Hot Carbonate Process—using hot, concentrated solutions of SOLVAY® Potassium Carbonate. It's ideal for removing carbon dioxide under conditions of fairly high concentration and partial pressure from process gases.

You save over other methods because the circulating carbonate solution is used hot. This eliminates costly heat exchangers and reduces the process steam requirement.

To help you compare the hot potassium carbonate method with other gas-scrubbing processes, mail the coupon for any of the six authoritative articles from major chemical and petroleum publications or the booklet, "SOLVAY Potassium Carbonate."

Sodium Nitrite • Calcium Chloride • Chlorine • Caustic Soda • Chloroform Caustic Potash • Potassium Carbonate • Sodium Bicarbonate • Soda Ash Monochlorobenzene • Para-dichlorobenzene • Ortho-dichlorobenzene Ammonium Chloride • Methylene Chloride • Carbon Tetrachloride • Vinyl Chloride • Methyl Chloride • Ammonium Bicarbonate • Hydrogen Peroxide Snowflake® Crystals • Aluminum Chloride • Mutual® Chromium Chemicals Cleaning Compounds

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- ☐ "CO_2 Removal from Natural Gas"—Oil and Gas Journal.
- ☐ "Economics of Acid-Cas Removal"—Oil and Gas Journal.
- ☐ "Improved Process for CO_2 Absorption"—Chemical Engineering Progress.
- ☐ "Which CO_2 Removal Scheme Is Best?"—Petroleum Refiner.
- ☐ "Florida's First Synthetic NH_3 Plant"—Chemical Processing.
- ☐ "SOLVAY Potassium Carbonate" fact book.

Name_____
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Address_____
City_____ Zone_____ State_____

are immoral for working in it. If it is corrupt, then you are tainted with the same corruption. If it is degraded, then you who work in its ranks cannot hold you heads high. Its shame in your shame, its guilt your guilt.

"And every accusation made against this industry is a personal accusation made against you.

Guilty or Not? "How do you plead? Are you guilty, or not guilty?"

Of course, your answer comes slamming back: "Not guilty!"

That's good, we'll take your word for that—but what are you doing to prove it? You've been accused, and the names of you and your business associates have been blackened by what you know is malicious and sometimes irresponsible reiteration of lies and halftruths. But again we ask, "What are you doing about it?"

How you answer really depends upon the type of individual you are. Some of you will sit idly by, hoping perhaps that with time people will forget these charges. This is the small boy caught with his hand in the cookie jar attitude. Others will speak up—they'll hotly deny that any of these charges are true, then they'll sit back and rest from the exertion of momentarily defending themselves and their industry. This is a somewhat negative approach for which the oil industry is becoming famous. In other words, we spend time saying, "No, we didn't do those terrible things," and as a consequence we either don't have or don't take time to publicize the industry's credits—and they are legion. We're proud of the oil industry for many reasons.

And we must promulgate all these favorable facts—we must take time to explain to the American people that these Honorable men in Washington are offering information which is all out of perspective. You cannot deny that in the fight for good public opinion and relations, we have lost battle after battle. And if we, and our industry, are to survive as an important segment of the American system of free enterprise, we cannot afford to lose the war.

Roses by Any Other Name—

THESE DAYS, it's not uncommon to hear many different voices rising in protest against the increasing role being played by our government in the internal affairs of this country. Top economists, business leaders and yea, even some Congressmen, are contending that our government is trying to keep too many fingers in too many different pies.

Therefore, it seems quite strange to hear one rabble-rousing voice from out of the wilderness shouting that the American government should assume more and more responsibility for individual welfare. Howevér, that's what a recent issue of the Oil, Chemical & Atomic Workers "Union News" amounted to. The issue contended that this country needs "to remove corporations from those activities which they should not engage in and to move government into some activities which the corporations have taken over."

Here are a few examples of what the "Union News" had in mind:

1. Social Security is the business of the public, not of corporations. Therefore all pensions, health insurance, sick leave and the many other protections we seek against emergency should be handled through nationalized insurance, replacing company-sponsored plans.
2. Manipulation of the nation's finances should be placed more securely in government hands.
3. Research and development of military equipment should be taken away from corporations and done by the government.
4. Public works and government guarantees of full employment should be expanded so that people would not be entirely dependent on corporate policy for employment.
5. A corporation should not be allowed to deduct from taxes as a business cost any money spent for advertising or publicity, except when this expense is solely and clearly for the purpose of selling merchandise. This would in part, though not entirely, take corporations out of the public brainwashing business.
6. Corporations should be required to reveal to the public, since they are publicly owned, more facts about their operations.
7. If Congress is to continue conducting "investigations"—and it is debatable if these investigations do any good—there should be searching investigation into corporation corruption and racketeering.
8. It should be public policy to encourage organization and strengthening of unions since unions supply a countervailing power against the tremendous power of corporations.
9. Above all, there should be a concentrated campaign by labor and liberal forces to call attention to the power wielded by corporations so that the people may be on guard, just as the residents of a river valley must watch with suspicion heavy storm clouds upstream.

The editorial goes on to admit that many readers will call this type of program socialism. "Well," continues the editorial, "we are not calling any names."

You bet, they're not calling any names. They don't want to be known as socialistic, but chances are they can't think of anything else to call such a liberal movement.

One of the principal tools we employ to reduce the element of chance (in the conduct of business) is research, which is nothing more than the pursuit of fundamental truth.

—Mark W. Cresap, Jr., *President*
Westinghouse Electric Corp.

Sparking sample for spectrographic determination of phosphorus.

Announcing new methods for rapid determination of phosphorus in gasoline

Ethyl Research develops spectrographic and colorimetric procedures

In recent years, phosphorus compounds have been used extensively as gasoline additives to combat surface ignition and spark plug fouling. Indications are that phosphorus deposit modifiers will be even more important in the future. This has created a need for rapid methods to determine phosphorus in gasoline.

Ethyl's Detroit Research Laboratories have developed two analytical procedures to satisfy this need. One of these is spectrographic and the other colorimetric.

Both procedures apply to a wide variety of phosphorus compounds. And they can be used effectively on gasolines containing additives such as tetraethyllead, antioxidants, dyes, and metal deactivators.

Spectrographic Method

Phosphorus concentrations* of 5 to 75 mg. per liter of gasoline can be determined by the spectrographic method with a standard deviation of 0.8 mg. per liter. A single phosphorus determination can be made in 30 minutes; a two-man team can make 70 such determinations per day.

The gasoline is analyzed without pretreatment except for adding a radiation buffer and an internal standard.

The buffer solution, consisting of 60 percent dimethylformamide and 40 percent isopropanol, improves the phosphorus line intensity and also reduces the effects of base stock and additives. Triphenylarsine, added to the buffer as

Phosphorus concentration is frequently stated as "theories of phosphorus". A theory is the weight ratio equivalent to two atoms of phosphorus to three atoms of lead.

For more data on advertised products, use Readers' Service Cards, last page.

the internal standard, further reduces the effects of variations in sample and additive composition.

An inert atmosphere of argon prevents sample ignition. The argon also enhances the intensity of the phosphorus line.

Analytical curves are plotted to give phosphorus concentrations in units of grams per liter, or as "theories of phosphorus" for a given tetraethyllead concentration.

One curve can be used for samples containing commonly used phosphorus additives. Separate curves are needed for samples containing more volatile phosphorus compounds such as trimethyl phosphate, triethyl phosphate, and dibutyl hydrogen phosphate.

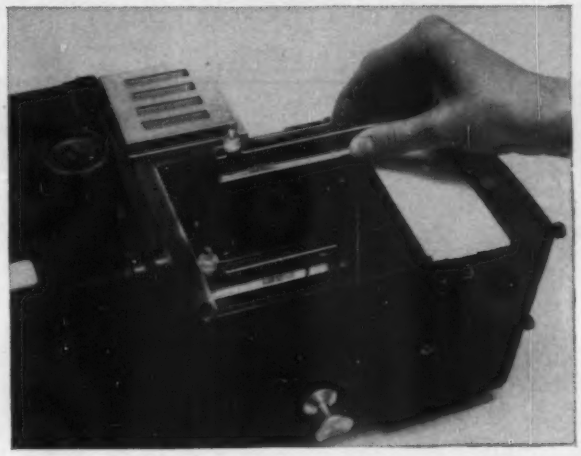
A correction is required for samples containing manganese.

Colorimetric Method

The colorimetric procedure is slower than the spectrographic method but more accurate. It can be applied to gasoline containing from 5 to 50 mg. of phosphorus per liter with a standard deviation of 0.5 mg. per liter. An hour is needed for a single determination; 24 can be made per man day.

The fuel sample is adsorbed on zinc oxide and ignited to oxidize the organic phosphorus. It is subsequently converted to the orthophosphate ion by dissolving in sulphuric acid. In this form phosphorus is readily measured in the presence of zinc, using a molybdenum blue method. Color obtained is stable and reproducible.

Ethyl's experience with a large number of gasolines containing a variety of antioxidants, dyes and metal deactivators has shown that these additives do not interfere with the determination; neither does manganese added to gasoline as (methylcyclopentadienyl)manganese tricarbonyl.



Inserting sample for colorimetric procedure.

Comparison of Spectrographic and Colorimetric Methods

	Spectrographic	Colorimetric
Sample size, ml.	4	1
Elapsed time for one determination; minutes	30	60
Determinations per man-day	35	24
Concentration range, mg./liter	5-75	5-50
Standard deviation, mg./liter	0.8	0.5
Base stock effect	none	none
Phosphorus additive effect	Additional calibration needed for volatile compounds	none
Manganese interference	Correction required	none

How Ethyl Research can help you

Copies of the paper, "Rapid Determination of Phosphorus in Gasoline," presented at the recent API Division of Refining meeting, are available through your Ethyl Representative. It is a detailed description of the analytical procedures outlined here.

The need for rapid methods to determine phosphorus in gasoline has arisen from the widespread acceptance of phosphorus additives as deposit modifiers. Ethyl has available three such additives. Two of these are free from any patent complications. Your Ethyl Representative will be glad to supply you with full details.

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ANTIKNOCK COMPOUND
ETHYL CORPORATION

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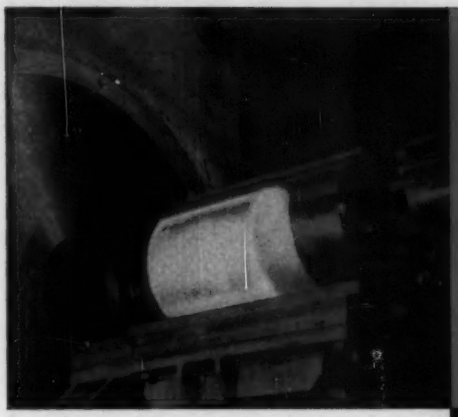
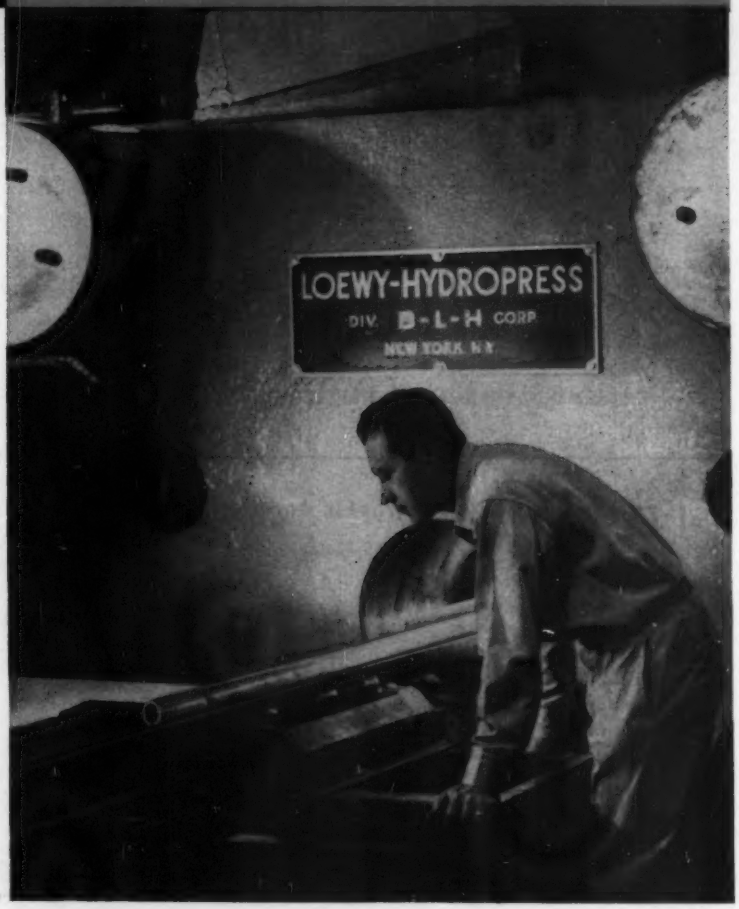
How lasting quality is Heat Exchanger



2 EXTRUDING

(SECOND OF A FIVE-PART SERIES)

Heated billet ready for insertion into extrusion press.



Billet emerges from extrusion press as a heavy-walled tube, or shell.

For more data on advertised products, use Readers' Service Cards, last page.

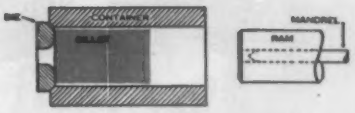
built into Phelps Dodge and Condenser Tubes...

Phelps Dodge heat exchanger and condenser tubes are formed from billets by the hot-forged extrusion process, a method that produces sturdy, seamless tubes with long service life, finest properties and precise dimensions.

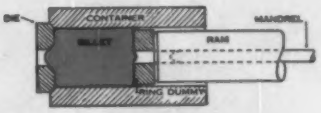
The metal billet, before being placed within the container of the extrusion press, is first heated in a controlled atmosphere to a temperature predetermined for each specific alloy. The subsequent forging (upsetting) and extruding operations are combined in a simultaneous operation.

The billet is forged by a compression system using several million pounds of hydraulic pressure. This operation refines the grain and achieves maximum densification of the billet. Finally, a highly polished steel mandrel is used to pierce the billet, thus forcing extrusion of the metal over and around the mandrel and through a steel die into the form of a heavy wall tube.

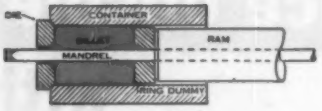
Throughout the entire tube fabricating operation—from raw materials to finished product—quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.



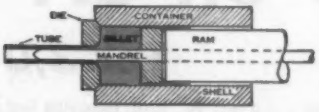
Billet is placed within container for forging operation.



Heated billet is forged within container through action of the ram pressing on the ring dummy-block.



Steel mandrel pierces billet just before extrusion takes place.



Hydraulic pressure exerted on ram and ring dummy-block causes metal to flow over mandrel and through die.

PHELPS DODGE COPPER PRODUCTS CORPORATION

First for Lasting Quality—from Mine to Market!

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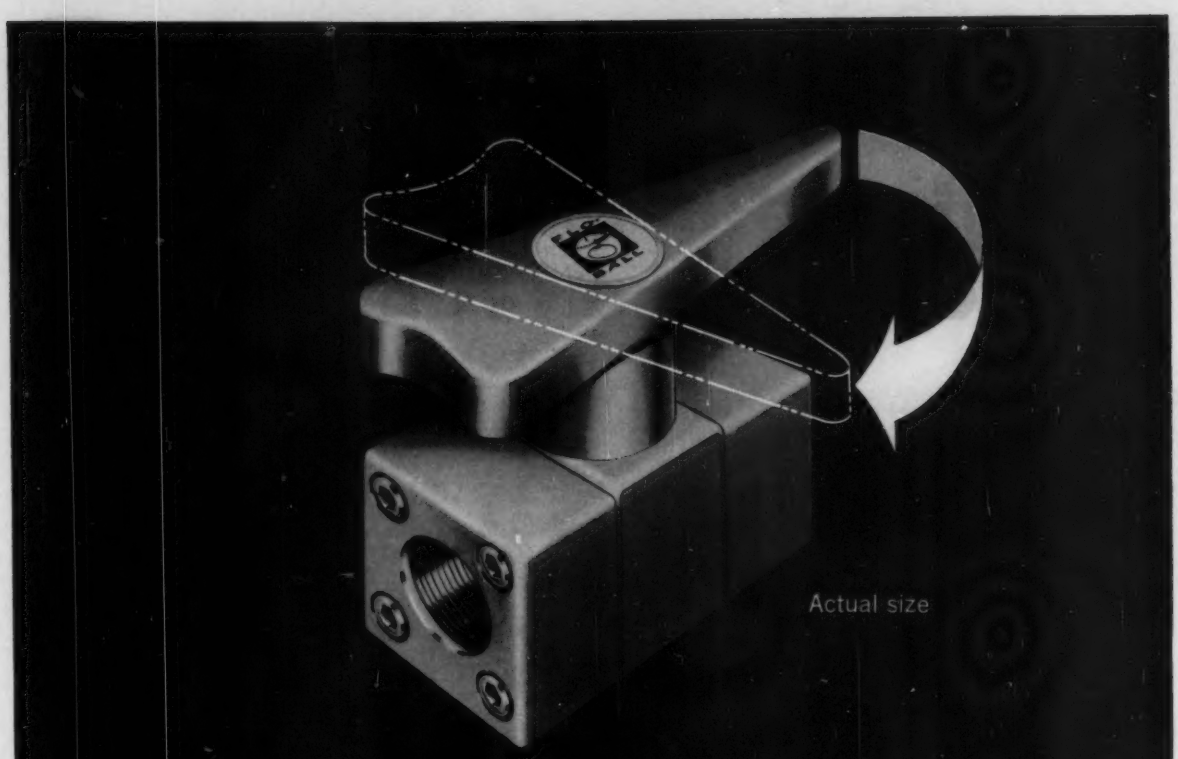

Replace obsolete needle valves with the NEW 90° ON-OFF *FLO-BALL*

For 3,000 PSI...

Low torque, instant action . . . a fast 90° turn, requiring just 4 inch-pound torque at 3,000 psi, actuates the valve instantly!

Priced no higher than needle valves!

100% flow efficiency . . . straight-thru ***FLO-BALL*** design has more than twice the flow efficiency of needle valves!

Positive ON-OFF indication . . . large arrow-shaped handle shows valve position at a glance!

Zero leakage . . . Mass Spectrometer tests with Helium prove zero leakage!

Universal mounting . . . can be panel, side, bottom, or line mounted!

Removable flanges . . . damaged flanges can be removed in seconds; no need to replace entire valve!

All stainless steel construction . . . costs no more than old fashioned screw-type valves!

Versatile service . . . ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, and many other fluids.

SERIES 715			
Port Styles and Sizes			
NPT		AND10050	
Size	Part No.	Size	Part No.
⅛	715A1	¼	715A2
¼	715B1	⅜	715B2

Other models are available for service with cryogenic and corrosive media. Also special designs for throttling flow control.

Write today for new catalog describing the world's most complete line of precision valves for industrial and military applications.

FLO-BALL

Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX=LIVINGSTON, N. J. 120

A LETTER FROM SOHIO TO M. W. KELLOGG

"We are well pleased with the performance of this integrated unit. It has performed with fewer startup troubles than we had anticipated, and it has demonstrated considerably more operating flexibility than we had expected . . ."

(Signed) **F. J. SANDERS, Engineering Manager**
The Standard Oil Company (Ohio)
Cleveland, Ohio

The above is an excerpt from the letter of acceptance from The Standard Oil Company (Ohio) to The M. W. Kellogg Company for SOHIO's recently dedicated 60,000 BPSD refinery at Toledo. Kellogg is privileged to have been able to work with Dr. Sanders and the many others at SOHIO in making this highly integrated $40 million refinery an economic success. For those wishing to obtain the complete story on the project, write Kellogg for the SOHIO Kelloggram—a 20-page booklet devoted to the refinery's engineering, construction, and operation.

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N. Y.
A SUBSIDIARY OF PULLMAN INCORPORATED

The Canadian Kellogg Company, Limited, Toronto
Kellogg International Corporation, London
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KELLOGG

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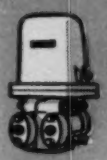
Indicating Motion-Type Transmitters

...for flow, pressure, and level

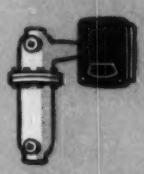


Low Displacement Force-Balance Transmitters

...for flow, pressure, and level

Thermocouple and Resistance Bulb Converters

...magnetic amplifiers...no vibrators
...no mechanical rebalancing



Displacer Level Transmitters

...force-balance for simplicity

Control Valves

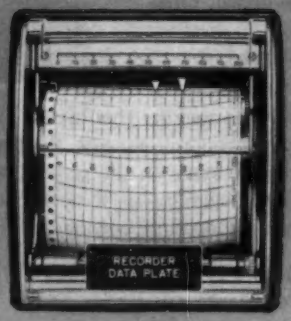
...electro-pneumatic and electro-hydraulic actuators

CONTROLLER

The Electronic Consotrol Controller (shown 4/5 actual size) concentrates all control and supervisory functions in one slim 3 x 5 inch case. Controller operation is entirely independent of recorder.

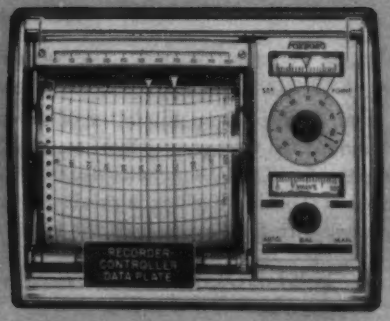
FOXBORO Electronic

REG. U.S. PAT. OFF.



RECORDER

Electronic Consotrol Recorders (shown ¼ actual size) use a simple, powerful pen motor which can be operated directly from transmitter signal without amplification. Available in 1 and 2 pen models.



COMBINED RECORDER-CONTROLLER

Electronic Consotrol housing design permits unequalled flexibility in panel arrangement. Recorders and controllers can be mounted separately in individual housings—or enclosed in a compound unit. Regardless of mounting, either unit pulls out independently.

for the first time... the 100% solid state electronic system!

- thermocouple and resistance bulb converters-using magnetic amplifiers
- choice of force-balance and motion-type transmitters
- long time-constant tubeless controllers

Consotrol Instrumentation

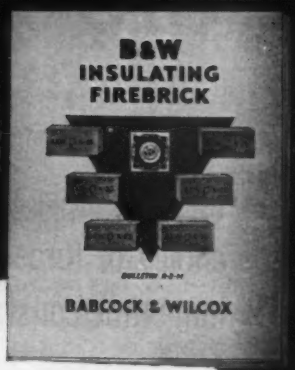
Electronic Consotrol* Instrumentation—the most complete and advanced family of electronic-operated measurement and control instruments available today! That just begins to describe Foxboro's dramatic new advance in instrumentation. ✓ ✓ ✓ Foxboro electronic transmitters, indicators, recorders, control stations, computing stations, valve actuators and other final operators cover every function in the control loop. All are linked by a d-c current signal. All are completely tubeless. Even thermocouple and resistance-type systems no longer require vacuum tubes. ✓ ✓ ✓ Electronic Consotrol systems convert temperature, pressure, flow, level, and other measurements, to a proportional signal **at the transmitter.** Transmission to a remote control station is instantaneous. Designs are available for both hazardous and non-hazardous areas. ✓ ✓ ✓ Electronic Consotrol Instrumentation heralds a whole new era in process control engineering. Write Foxboro today for the new 32-page Catalog 21-10 which gives full details. **The Foxboro Company, 748 Neponset Ave., Foxboro, Mass., U.S.A.**

*Reg. U.S. Pat. Off.

Foxboro urges you to attend the I.S.A. Show in Chicago, Sept. 21-25

Why B&W IFB for Oil Heater Linings ?

- Lightest weight
- Simplified construction
- High hot load strength
- Lower conductivity
- Lower heat storage
- Better process control



The light weight of B&W Insulating Firebrick provides savings in capital investment in several different ways. The light weight of B&W IFB permits thinner wall constructions of equivalent insulating value. These thinner, lighter walls mean real savings in structural steel and concrete. Construction is further simplified because B&W IFB's high hot load strength makes possible higher unsupported walls without deformation at furnace operating temperatures. In addition B&W IFB can be cut and shaped with ordinary wood working tools, simplifying field installation.

The light weight of B&W Insulating Firebrick also provides the greatest insulation. Thus, they save more fuel.

Light weight also means lower heat storage. B&W IFB protect you against burn-out of expensive alloy tubing in the event of forced shutdown. B&W IFB respond faster to changes in firing rate, too, assuring you of more positive process control.

**Write for Bulletin R-2-H giving more data on B&W Insulating Firebrick.*

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COOPER ALLOY VALVE BRIEFS

THE VALVE AND FITTINGS ANSWER CORNER

Send in your questions on stainless valves and fittings to Carl Tylka, Cooper Alloy Technical Service Director.

Q. *Is it possible to obtain a valve which, like a globe valve, possesses linear throttling characteristics, but which also, like a gate valve, has low fluid pressure drop across it when fully opened?*

A. Not throughout the entire flow range of the size valve being considered. A very close approximation, however, may be attained with a Flex-Plug type design (a unique new valve patented by Cooper Alloy), which provides linear throttling response up to 90% of full valve flow. The 10% balance of the upper flow region would exhibit a typical gate valve flow pattern.

Q. *How can one prevent oxidation of active ferrite ion on the fluid side of a cast stainless valve body?*

A. This type of corrosion is commonly found on untreated cast stainless surfaces only, and may be caused by foundry, machinery, and handling techniques. Proper pickling and passivation with thorough mechanical cleaning will generally rectify this, though in some cases actual weld repair of the contaminated surface is required. Since this is a surface condition only, machining or grinding will also help.

Q. *What type of valve do you recommend for manual-control services where minimum pressure drop is required?*

A. In the absence of more detailed knowledge of the problem, I would tentatively recommend an angle valve. The pressure-drop characteristics of this type valve are less than 50% those of conventional globe valves.

Q. *Is it advisable to specify installed valve position on an order?*

A. Definitely. By inclusion of this information, definite design considerations can be incorporated, especially in cases where backseat leakages are critical and mechanical valve operation is involved.

Q. *Is it advisable to install valves smaller than the accompanying pipe sizes?*

A. Where flow and pressure considerations so permit, it is not only advisable but also economically beneficial.

Q. *Why aren't valve bodies with butt weld and connections made shorter?*

A. To prevent distortion of the seating surfaces during installation. The longer length is required for heat dissipation during welding.

Above left, Cooper Alloy 16" cast stainless gate valve ready to receive gear motor drive; lower left, Cooper Alloy 12" cast check valve. Both are rated for 2500 psi service at 670°F. Official AEC photo above shows them in place in nuclear process line.

Cooper Alloy cast stainless valves spurt ahead of competition to win acceptance in AEC's Spert III reactor program

Cast yield strengths of 23,000 psi, plus cost savings of 40%, do the trick!

This is a Cooper Alloy success story in another "first": casting of stainless valves and fittings to strength levels actually surpassing those previously possible only in forgings—and doing it all at a 40% saving to the customer!

The story starts, naturally, with the AEC's valve and fitting specifications, which are rugged indeed. They have to be certified to function continually at elevated pressures and temperatures (2500 psi, 670° F.), under which conditions leakage, corrosion, and other operational problems are magnified enormously over those encountered in normal process work.

Prior to turning to Cooper Alloy, the contractor for the AEC cancelled a large valve order from another supplier, because the latter could not meet the exacting physical specs without changing the material specs. Cooper Alloy was given the order on the basis of producing to meet AE and AEC specs. Cooper Alloy valves and fittings are currently in operation in the AEC's Spert III installation at Arco, Idaho. Included are nuclear fittings, and motor and manual operated gate, globe, and check valves in various sizes.

How does Cooper Alloy do it? Through the use of the most advanced foundry methods, meticulous attention to conditions, and an exact balance of chemical composition to develop the maximum strength characteristics inherent in the complex structure of stainless alloys. All products, naturally, are elaborately tested and guaranteed before delivery.

As if the AEC's specs were not stringent enough, there is now a bonus to the story: during production, Cooper Alloy technicians worked out ways of producing cast strengths higher than those required, and proceeded to produce all fittings and valves to these higher, self-imposed standards—at cost savings of 40% over forged valves and fittings!

Unusual, yes, but not to Cooper Alloy. It's typical of the quality bonus you get when you buy from Cooper Alloy. For further information, write to Cooper Alloy Corporation, Hillside, N. J.

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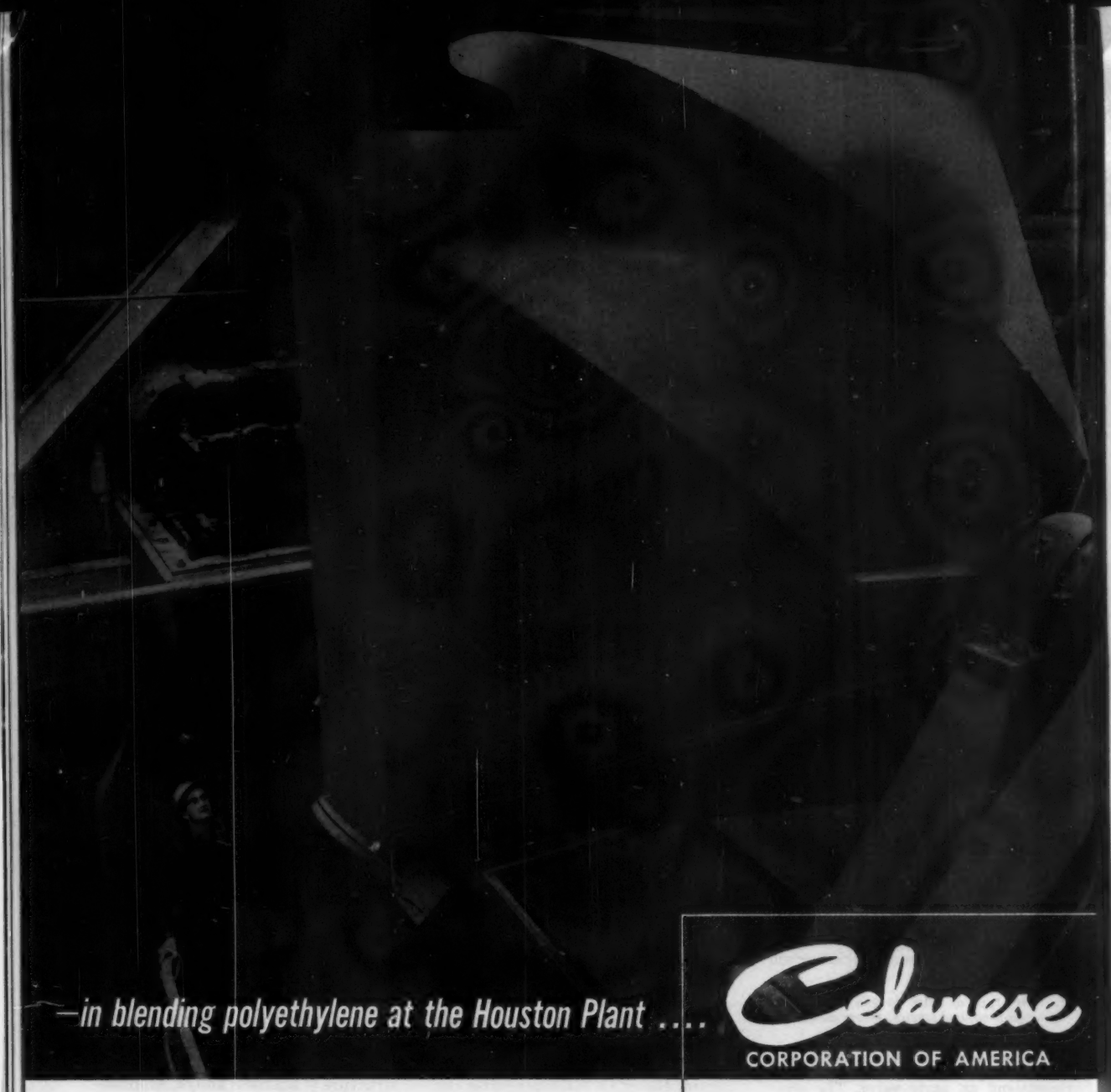

—in blending polyethylene at the Houston Plant ....

Celanese
CORPORATION OF AMERICA

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6 Patterson THORO BLENDERS

for

- UNIFORMITY OF PRODUCT
- SHORT BLENDING CYCLE
- RAPID EASE OF CLEANING

Achieving complete homogeneity of blend in remarkably short cycles, the Patterson ThoroBlenders serving Celanese Corporation at their Houston Plant cross-blend the entire production output of polyethylene, in both pellet and flake form.

The plant is equipped with 5 production ThoroBlenders ranging in size from 8 ft to 14 ft in diameter, and a 6 ft pilot model. Bodies of all ThoroBlenders are of stainless steel, and the production-size units are equipped with air-operated charge and discharge doors.

If, like Celanese, you have a need for faster, completely uniform product blending in dependable, easily-cleaned units, we suggest you check the advantages ThoroBlender can bring to your operation. Write, phone or wire for a prompt consultation.

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A Division of Ferro Corporation
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THE Patterson FOUNDRY AND MACHINE CO. (CANADA) LTD.

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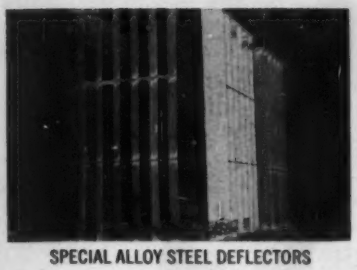
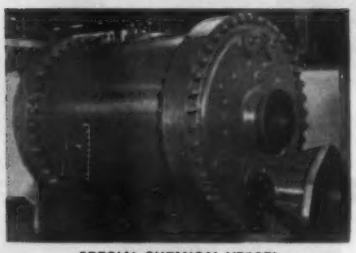


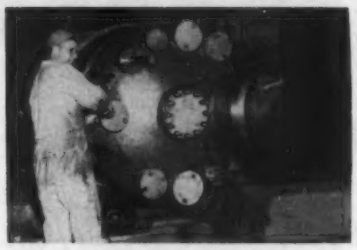
SPECIAL ALLOY STEEL DEFLECTORS



SPECIAL CHEMICAL VESSEL

SPECIAL STAINLESS VESSELS

TOWER, 8'6" dia. x 154' in length



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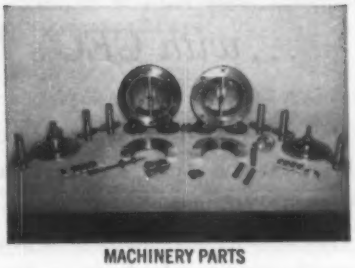
SPECIAL CONDENSER

WATER SHIPMENT



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. . . with CEC's Mass Spectrometer/Chromatograph team

This time-proven pair affords laboratories one of the broadest and most powerful analytical systems yet devised. Both units are basically complementary. CEC's Type 21-620 Mass Spectrometer delivers very fast analyses of vapor samples having masses up to m/e 300 . . . while the CEC Type 26-201A Chromatograph separates samples into time-spaced, single-component peaks with accuracy in parts per million.

These features permit the mass spectrometer to hasten identification of chromatographic output, and the chromatograph to provide simple, easy-to-analyze components for mass-spectrometer analyses. Used as a team in research or quality-control laboratories, they facilitate analyses of complex hydrocarbons, biological compounds, and many similar materials—to achieve rapid equipment payout.

Analytical & Control Instrument Division CEC

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21-620 MASS SPECTROMETER — Mass range from 2 to 150 with unit resolution. Now available with an isotope-ratio determination accessory to permit comparison of two peaks. Fast response of one second is coupled with long-term calibration stability. Write for Bulletin CEC 1824-X33.

26-201A LABORATORY CHROMATOGRAPH — Modular — consists of separate control and analyzer units. An exclusive thermostatted pre-cut column reduces time for complex analyses to minutes. Instrument can be made to sample directly from high-pressure containers and precision valve gives better than ±0.5% reproducibility. Write for Bulletin CEC 1831-X28.

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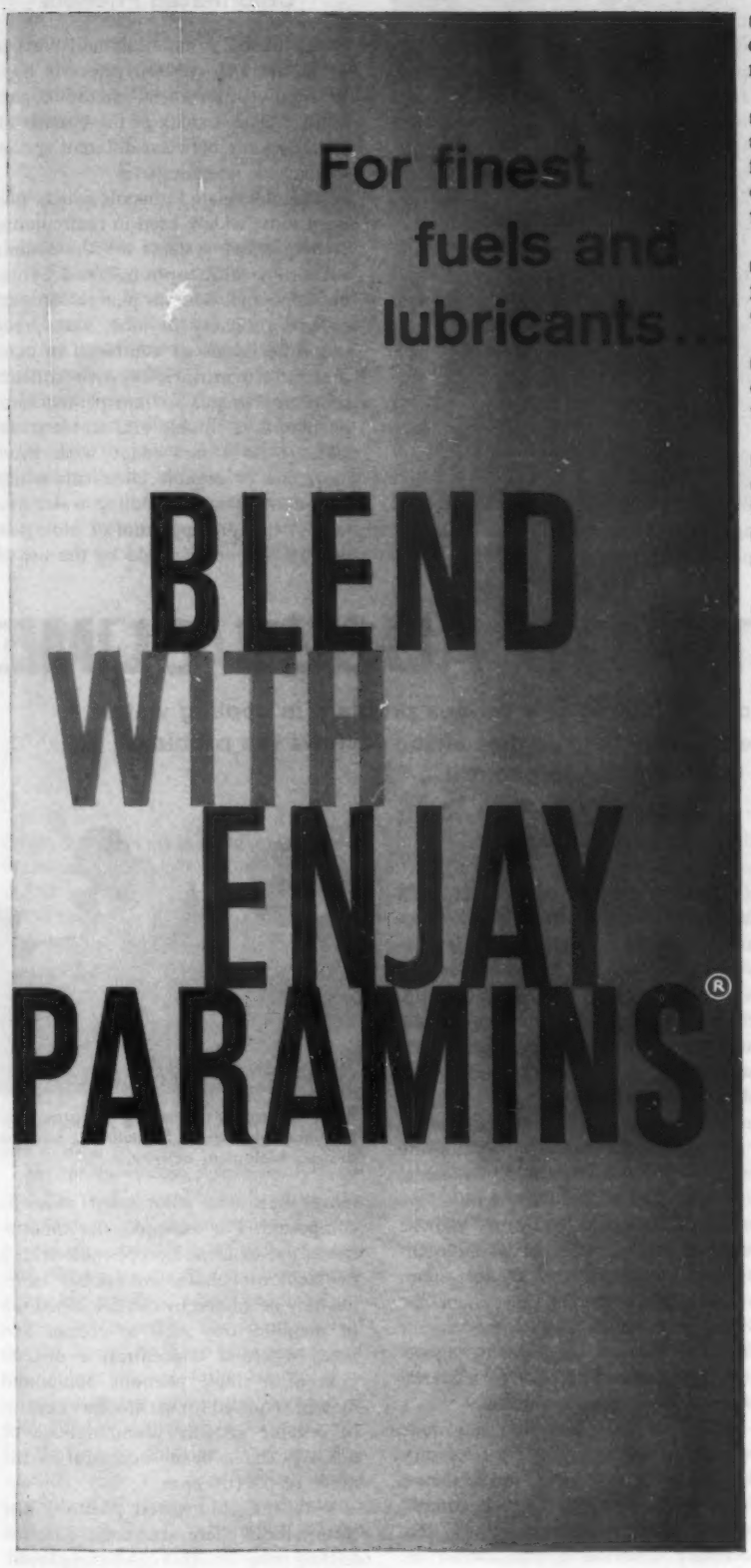

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detergent inhibitors retard oxidation and minimize creation of harmful deposits.

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viscosity index improvers build high "VI" for cold weather quick starting with low consumption and reduced friction characteristics.

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pour-point depressants insure oil flow in cold weather.

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dewaxing aid increases filter rate and dewaxed oil yield.

ENJAY PARABAR®
oxidation and rust inhibitors produce stable industrial oils that protect critical metal surfaces from corrosive effects of oxidation and moisture.

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oil and fuel improvers impart oxidation and anti-rust characteristics to fuel oil and gasoline.

ENJAY PARAPOID®
gear oil additives improve load-carrying and anti-weld properties of gear oils for maximum protection of gears under extreme-pressure service conditions.

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lubricants tackiness agents impart cohesiveness to any oil or grease.

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HELPFUL WATER CONDITIONING DATA FROM BETZ

WHAT TO DO ABOUT SLIME

Biological fouling is a serious problem in cooling water systems. This helpful discussion reviews the problem and tells what to do about it.

BIOLOGICAL fouling in cooling water systems is the result of excessive growth and development of slime and algae. The principal difference between the two is that algae are capable of manufacturing their own food; fungi cannot.

Algae commonly are found in all surface water supplies. They range in size from unicellular microscopic plants to plants of more than one hundred feet in length. Although these plants are found usually in fresh and salt water, a few species are terrestrial. The species which are of primary importance in cooling water systems are the microscopic fresh water types, however, under unusual conditions the larger marine types also may become an industrial menace.

Because sunlight is necessary for the growth and development of these plants, recirculating cooling water systems are plagued with the problem of algal growths to a greater extent than once-through systems where the cooling water is not usually exposed to direct light. Abundant algal growths in spray ponds and in cooling towers will interfere with proper water distribution and thus prevent the desired cooling effect. Large masses of algae will plug screens and restrict flow in pipelines and pumps. Living algae in the presence of sunlight carry on processes of photosynthesis which result in the manufacture of food and the liberation of oxygen. Masses of living algae on metal surfaces can accelerate corrosion in the form of pitting because of the depolarizing action of the oxygen released. Accumulations of dead algae lodged in heat exchange units also can set up local cell action which can cause severe pitting of the metal.

Slime is an accumulation of microorganisms and whatever inorganic and/or organic debris may become embedded in the mass. The microorganisms usually found in these deposits are members of the filamentous fungi, yeasts, and bacteria. Slime also may contain dead algae which have been entrapped in the mass. In general, dark areas or those of low light intensity are more favorable for this type of biological fouling. The microorganisms do not utilize light to manufacture their food, being totally dependent upon the food available in the cooling water system.

The most common varieties of bacteria and fungi found in cooling systems are the air-borne types. The slime forming bacteria have a gelatinous capsule which not only serves to entrap other materials which add to its bulk, but also serves to protect the bacteria against the action of chemical and physical agents.

Chlorine

Chlorine is probably the agent most widely used for control of microbiological deposits in recirculating systems. In the absence of substances which cause a high chlorine demand, chlorine is usually the most economical method of treatment. It is highly toxic and acts quickly to kill bacteria. A chlorine residual of 0.5-1.0 ppm will usually destroy most microorganisms.

However, the amount of chlorine required for the control of biological fouling in any individual system is governed by numerous factors. Chlorine requirements are affected by the quality of the makeup water to the system, water temperatures in the system, air to water ratio of the system, the amount of contamination by reducing agents and the type and amount of bacterial and fungal contamination.

For control of the slime and algae problem in any system, it is necessary that sufficient chlorine be fed to secure the required residual chlorine content of the treated water. Further, this necessary chlorine residual must be maintained in the system for the time interval required for microorganism control.

Chlorinated Phenols

Many phenolic materials and particularly the chlorinated phenols have found use in industrial microbiological control. The toxicity of these materials varies widely between different species of bacteria and fungi.

The chlorinated phenols which have been most widely used in recirculating cooling water systems are the sodium salts of trichlorophenol and pentachlorophenol. Sodium pentachlorophenate is probably in most widespread use either alone or combined in commercial formulations with sodium trichlorophenate. Sodium pentachlorophenate is a soluble and stable material. It does not react with most inorganic or organic chemicals which may contaminate a cooling water system. A broader spectrum of biological activity can be achieved by the use of more than one chlorinated phenolic compound. For example, the simultaneous use of a trichlorophenate with a pentachlorophenate. Additional benefits may be gained by the combined use of metallic ions such as copper and zinc. Where a concentration of 200 ppm of a single phenolic compound may be required for satisfactory control of organic growths, combinations of this type have been successful in the range of 60-100 ppm.

Betz laboratory screening program determines whether a formulation has the desired biological activity.

With the chlorinated phenols, like chlorination, there are many different feeding programs that can be employed, ranging on the one hand from the continuous maintenance of a high concentration in the circulating water to the

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other extreme of intermittent addition of the material in low concentration at infrequent intervals. As with chlorination, the slime control program must be fitted to the individual system conditions.

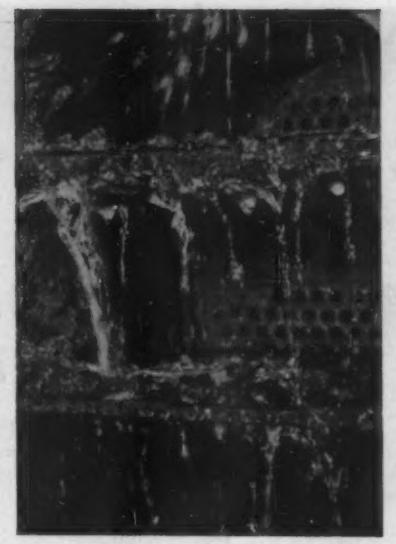
Selecting Slime Control Agents

A major factor in the decision whether to use chlorine or another slime control agent is usually made by balancing continuous chemical operating cost against equipment installation and maintenance costs.

Where liquid chlorine can be used, chemical cost will usually be lower than with other toxicants if chlorine is purchased in the larger one ton containers or tank cars, at their lower price. However, the installation cost of chlorinators and facilities for handling bulk chlorine shipments is quite appreciable. Maintenance of this equipment is an added cost.

On the other hand, other slime control agents are usually furnished in readily handled containers in liquid, powder or briquette form. Usually feeding facilities are not required when the toxicant is shot fed at infrequent intervals. Therefore continuous attention to feeding equipment is not necessary and there is no installation cost to be capitalized.

Where the system is sufficiently large and the problem sufficiently acute, the installation and maintenance expense of chlorination facilities will be justified. Where the cooling water system is relatively small or where there is only infrequent necessity for slime control agents, it will be more economical and convenient to employ agents other than chlorine. Even where the control of biological growths is handled normally by the use of chlorine, there will frequently exist the need of additional slime control agents. For example, during periods of contamination of the cooling water by reducing agents, chlorination facilities may be inadequate for the quantity of chlorine required under these circumstances.



Heavy slime formation in heat exchanger.

Addition of agents such as the chlorinated phenols or the various commercial combinations, may be necessary to control organic growths during such periods. Even where the increased chlorine dosage can be handled by the feeding equipment installed, it may be more economical to use another slime control agent at such times rather than to employ the greatly increased amounts of chlorine required during periods of contamination.

At the present time, there is no single toxic agent which is completely effective for the control of biological fouling in all types of industrial cooling water systems. There are faults inherent in all of the toxicants in common use. Chlorine is highly effective and rapid in bactericidal action, but chlorine consumption is greatly increased by the presence of reducing agents.

In addition, chlorine residuals can and often do have an adverse effect on cooling tower wood—particularly when residuals on the order of 1 ppm or higher must be maintained. Chlorine reacts with the lignin components of the wood and produces a bleached, fibrous surface. The cascading water readily washes away the weakened surface layers of the wood. With time the wood becomes thin and loses much of its strength. There is evidence that towers that use chlorine alone for slime control are more susceptible to fungus attack of the wood. Extensive damage from fungus attack is not uncommon and has been responsible for costly tower repairs and maintenance.

The chlorinated phenols and other materials may present a problem of fish toxicity in the blowdown discharge. Copper salts are more specific to algae than to bacteria and are rendered ineffective by precipitation at higher pH values. Quaternaries are affected by ions and organic matter.

All of these chemical agents are not equally economical and efficient. Selection of toxicants must be based on the microbiological complex encountered. Frequently, more than one toxicant is desirable to control, for example, both a bacteriological slime and/or algae

AND ALGAE

problem. Methods and frequency of chemical feeding must be varied to suit the individual problem. Slime control agents vary in the rapidity of their action and must be selected with a knowledge of the retention period in the system. Compatibility of the toxicant must be studied in relation to other treatments used for scale and corrosion control. Local conditions governing discharge of blowdown water from the cooling system must be considered. Selection of the proper method of control of microorganisms in cooling water systems requires evaluation of numerous factors.

A complete and detailed study of biological fouling in recirculating cooling water systems is available in Betz Technical Paper No. 134A. We will be pleased to send you a copy.

BETZ LABORATORIES, INC.
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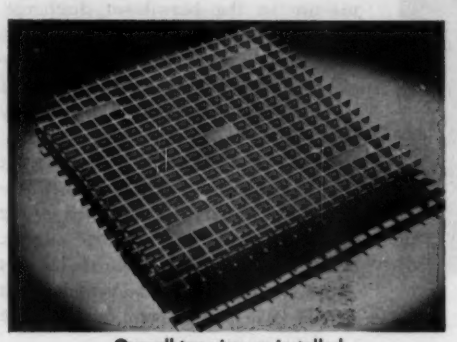
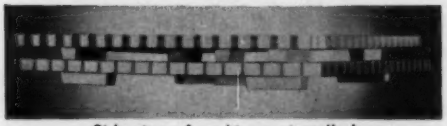
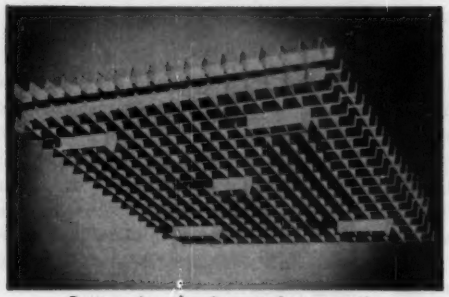


Overall top view as installed



Side view of packing as installed



Bottom view showing spacing supports

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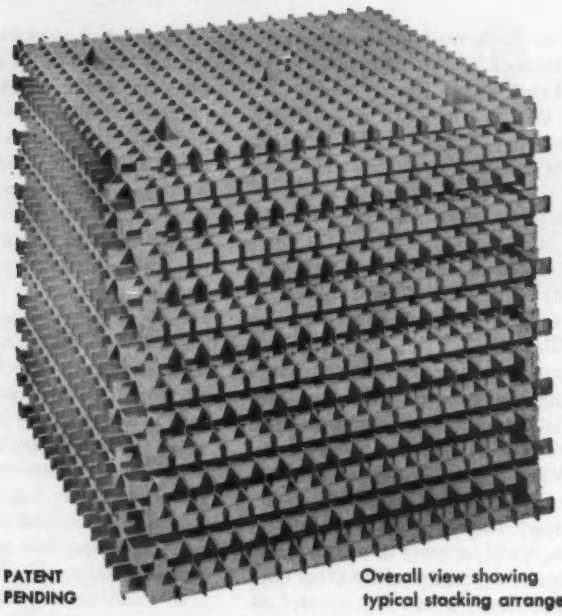

PATENT PENDING

Overall view showing typical stacking arrangement

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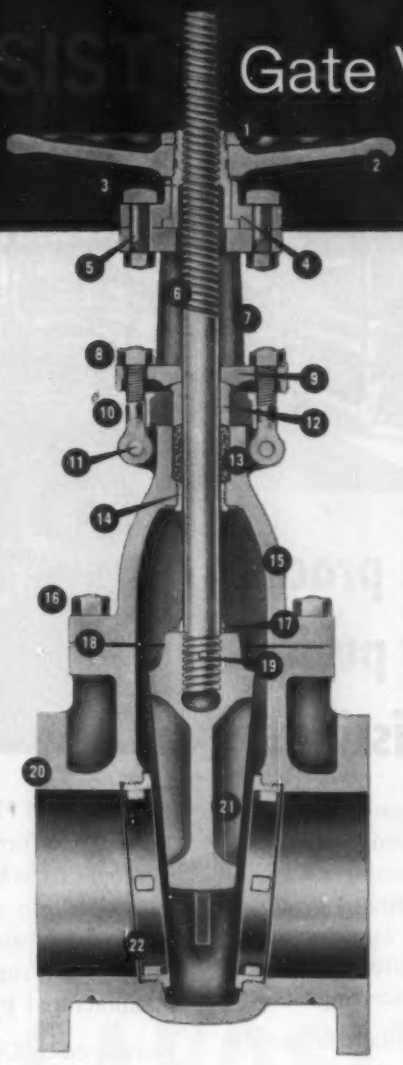

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No. 2... you get all the excellence which the Jenkins Diamond trademark has represented for nearly a century. The superior design and construction are visible here. Equally important superiorities which show up only in the records of long service and low maintenance are the close grain and high density of Jenkins castings... the precision of Jenkins machining... the rigid inspection and testing which every Diamond-marked valve undergoes.

It costs no more to buy Ni-Resist Gates made by Jenkins. And, it may cost much less to USE them. Write us, or ask your Jenkins Distributor for information folder No. 205.

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2 Handy grip iron wheel
3 Bronze yoke bushing
4 Iron yoke cap with zerk fitting for lubricating bushing
5 Steel yoke cap bolts and nuts
6 TYPE 316 STAINLESS STEEL spindle
7 NI-RESIST CAST IRON, TYPE 2, yoke
8 Bronze eye bolt nuts
9 Malleable iron gland flange
10 Steel gland eye bolts
11 Steel gland lug bolts and nuts
12 TYPE 316 STAINLESS STEEL gland
13 Teflon impregnated asbestos packing
14 TYPE 316 STAINLESS STEEL bonnet bushing
15 NI-RESIST CAST IRON, TYPE 2, bonnet
16 Steel bonnet bolts and nuts
17 TYPE 316 STAINLESS STEEL spindle ring
18 Asbestos gasket
19 TYPE 316 STAINLESS STEEL wedge pin
20 NI-RESIST CAST IRON, TYPE 2, through-port body
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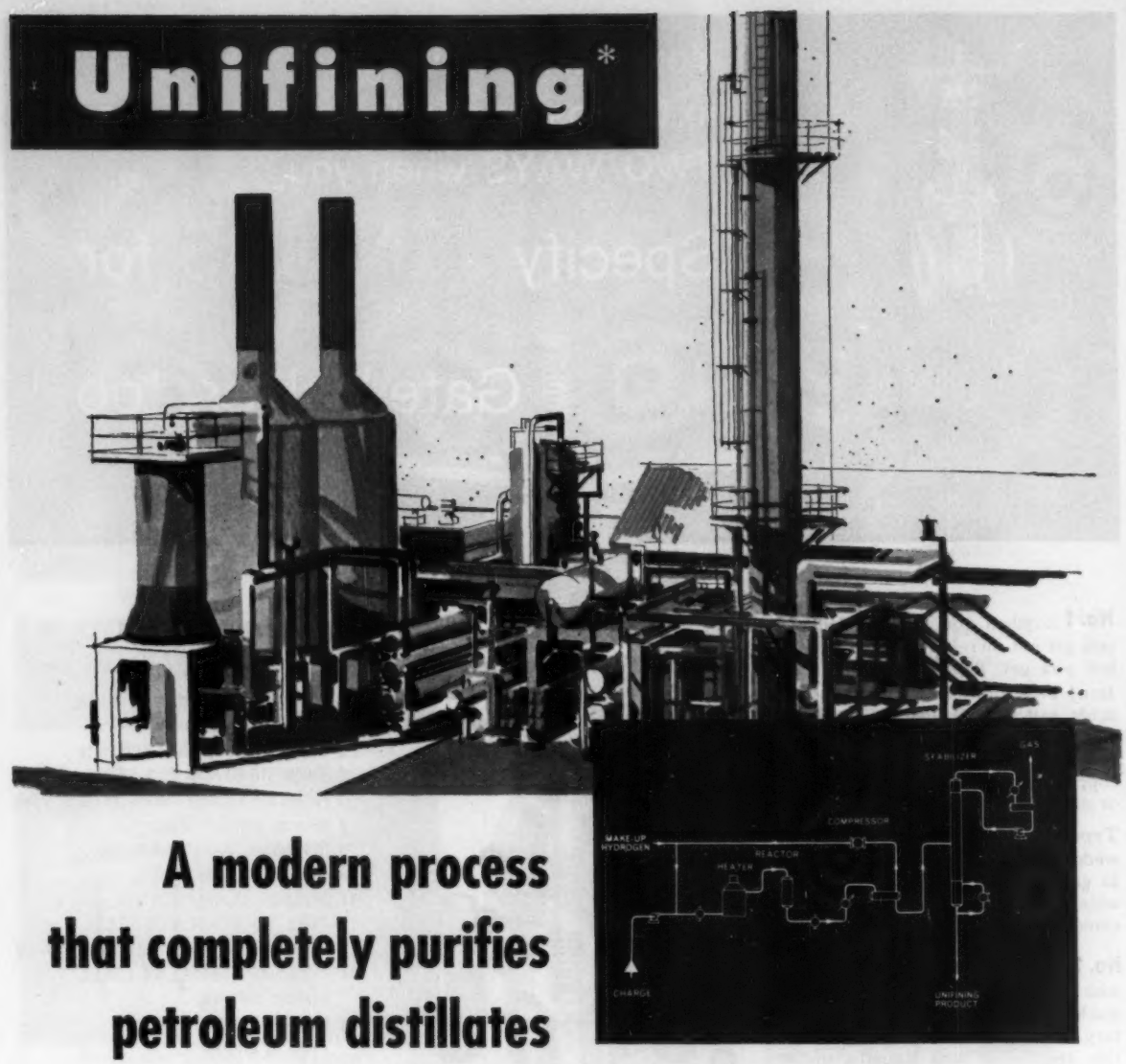

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In the Unifining process, simultaneous saturation of olefins also occurs, producing ideal virgin-like products that make further processing easier, or give greater stability to fuel oils.

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Developed by Universal Oil Products Company in conjunction with Union Oil Company of California, Unifining is available through UOP to all refiners.

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More Than Forty Years Of Leadership In Petroleum Refining Technology

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hot, coke-laden pumpage at high heads.

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- The pulverizing action on entrained solids reduces clogging of other system equipment.
- Non-pulsating flow eliminates need of auxiliary equipment for control of pressure and/or capacity.
- Eliminates expensive protective devices.
- Smooth pump characteristics eliminate destructive vibration.
- Lower maintenance. Only one moving part.

HANDLES COKE-LADEN HOT OIL IN CRACKING SYSTEMS WITHOUT CLOGGING

The Bingham "Koke-Krusher", the only pump that crushes coke, is a field-proven, centrifugal pump specially designed for the severe services of pumping oil products such as *Residuum, Flash Tower Bottoms, Black Oil Recycle*—in which the oil carries in suspension pieces of hard coke of irregular size and shape.

This revolutionary Bingham pump features a coke crushing mechanism located in the suction chamber immediately in front of the impeller eye. Any piece of solid coke entrained in the pumpage *must* pass through the crusher, where it is instantly pulverized, before entering the impeller.

The resulting pulverized coke particles are small enough to assure free flow through the pump and all system equipment. The Bingham "Koke-Krusher" will make a big difference in your operations. Call your nearest Bingham office for full details. Send for Bulletin 106.

PARTIAL LIST OF MAJOR OIL COMPANIES WITH BINGHAM KOKE-KRUSHER PUMPS IN OPERATION OR ON ORDER

ESSO Standard Oil Company
Gulf Oil Company
Texas Oil Company
Canadian Petrofina, Ltd.
Champlin Refining Company
Shell Oil Company
Sinclair Refining Company
Socony Mobil
Imperial Oil Company, Ltd.
McColl Frontenac Oil Co., Ltd.

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY

General Offices: **2800 N.W. Front Avenue, Portland 10, Oregon**

Factories: **Portland, Ore. • Vancouver, B. C., Canada**

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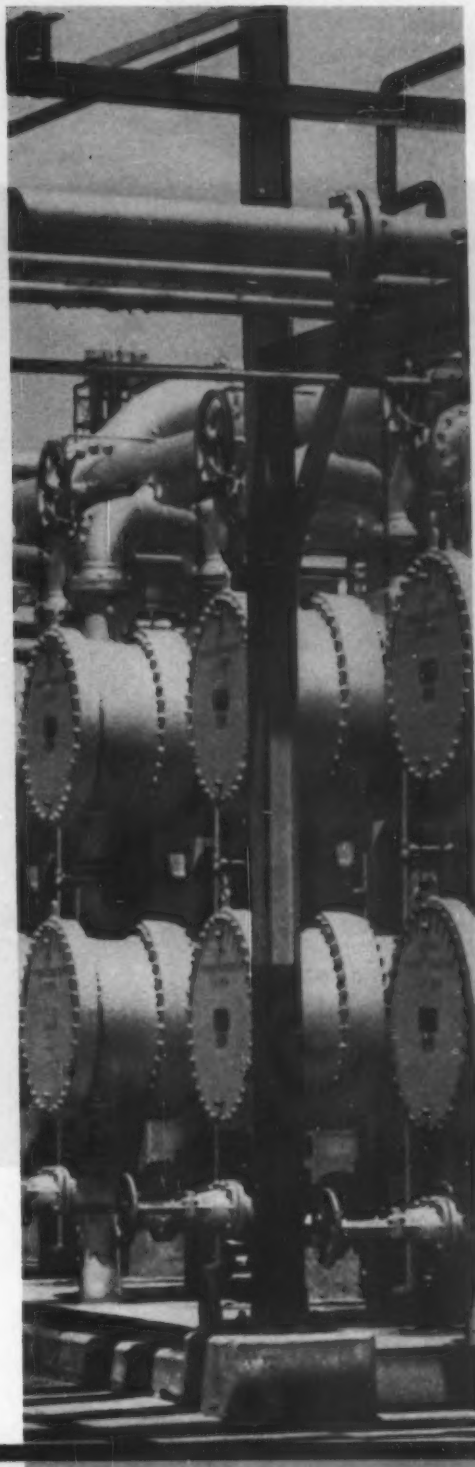
NEW ORLEANS, LA.
NEW YORK CITY, N.Y.
PHILADELPHIA, PA.
PITTSBURGH, PA.
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
ST. LOUIS, MO.
ST. PAUL, MINN.
TULSA, OKLA.
TORONTO, ONT., CAN.
VANCOUVER, B. C., CAN.

Oakite ECP
engineered cleaning program

saves 400 manhours in cleaning heat exchangers



Exchangers at Cat crackers "A" and "B" were both running fractionater bottoms through the tubes as well as gas oil on the shell side. The tube sides were OK, but shells became fouled with carbonized oil. The four tube bundles on "A" Cat were pulled and vat cleaned. Results: excellent. Cost $2730.

Then Oakite was called in to discuss in-place cleaning. An ECP* program was drawn up for the whole refinery . . . including a recommendation to clean tube bundles by chemical circulation. Arrangements were made for rental of circulation equipment by which a solution of Oakite 77 was pumped through the shells for 8 hours, and rinsed.

Results: again, excellent. Heat transfer coefficient was nearly identical to Cat "A". *Savings in manhours:* 400. *Savings in dollars:* $1595 . . . almost $400 per bundle.

WHAT IS OAKITE ECP*? It's an *Engineered Cleaning Program** that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite specialist lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research by *materials* known to make short work of refinery soils, by proved methods. Send for Bulletins. Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

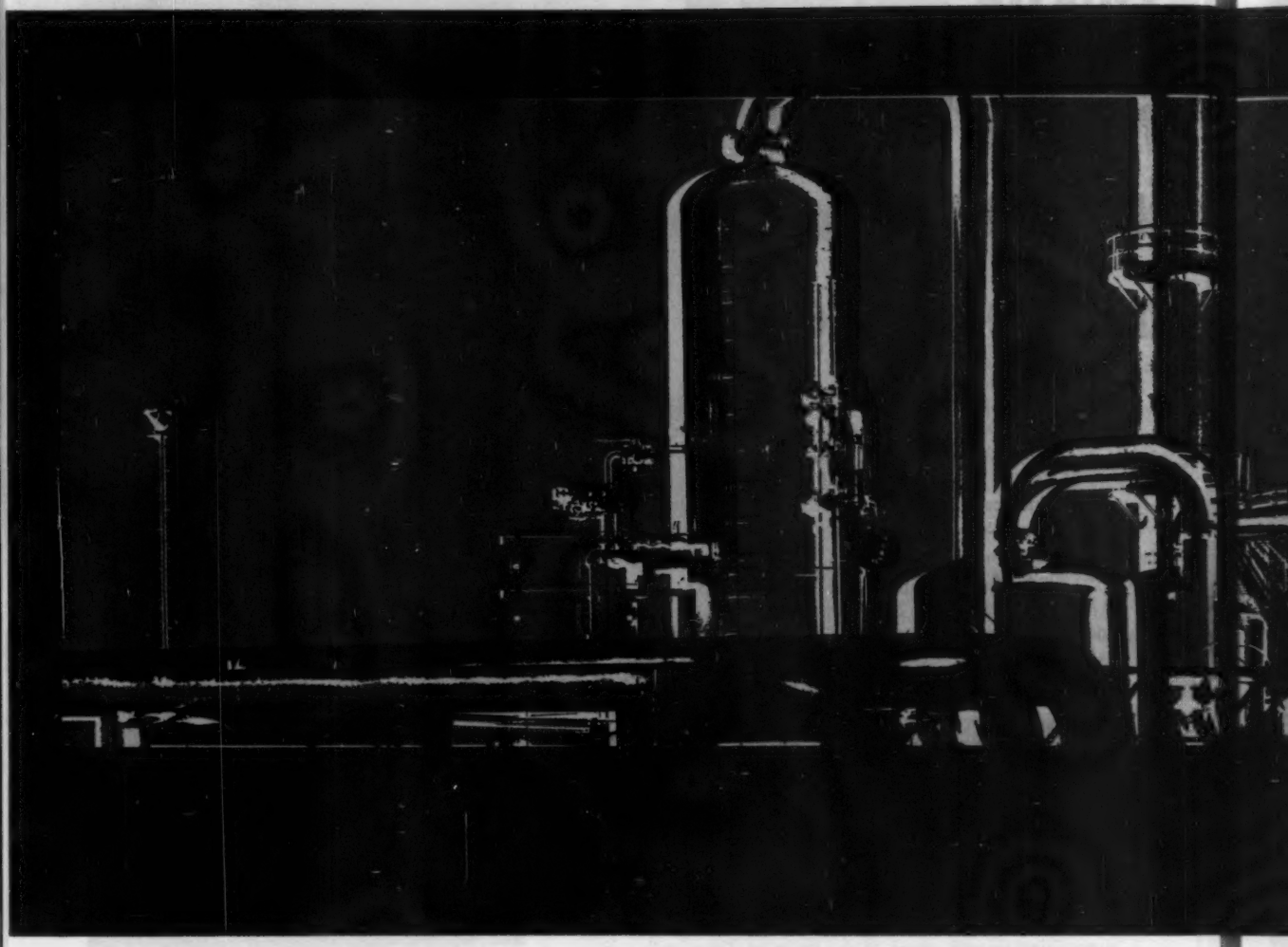
OAKITE
50 1909-1959 SCIENCE
years' leadership in industrial cleaning

Export Division Cable Address: Oakite

Technical Service Representatives in Principal Cities of U. S. and Canada

Oakite ECP
your economy key

For more data on advertised products, use Readers' Service Cards, last page.

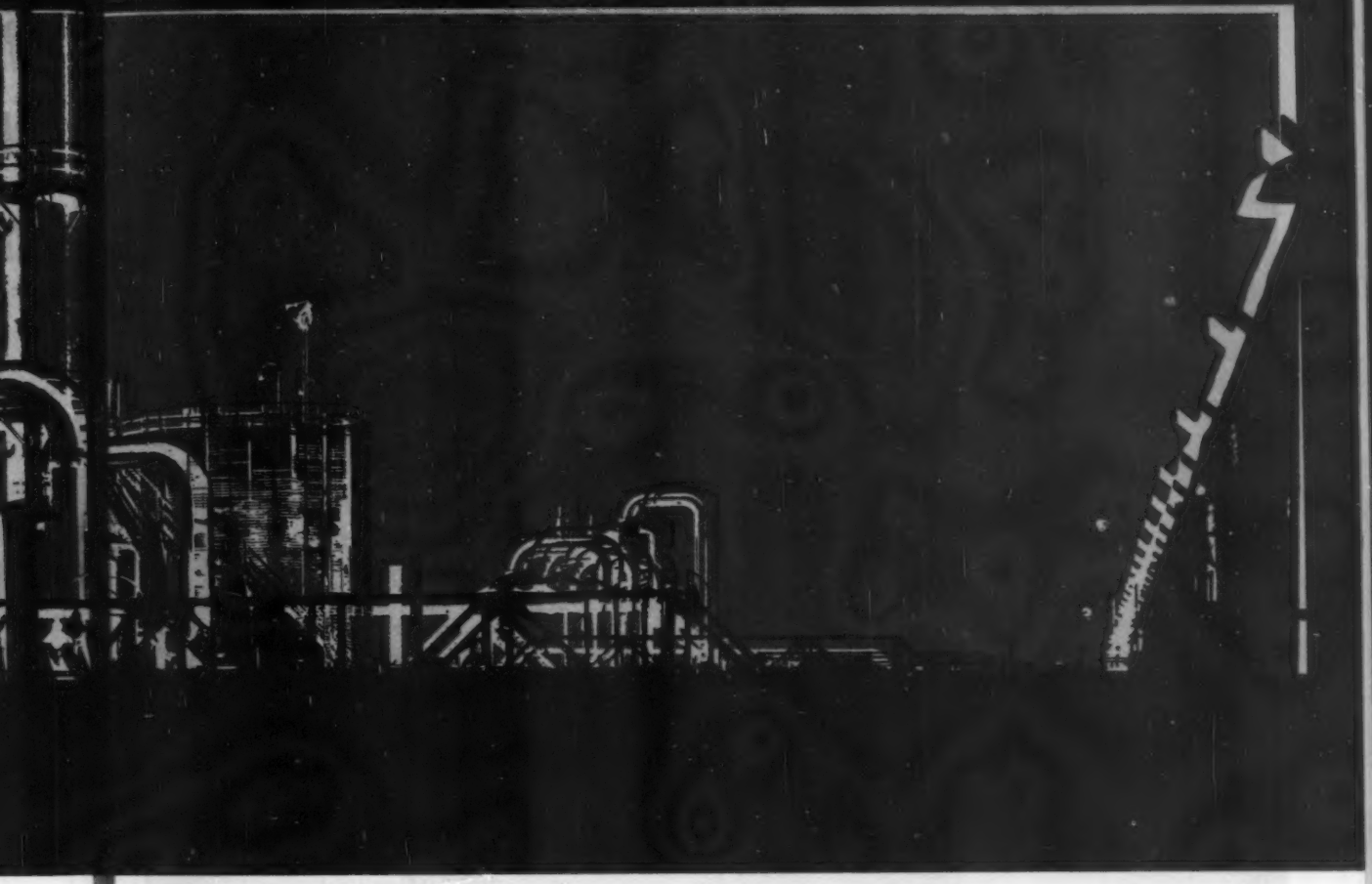


Dead or alive?

Each time tubular trouble jolts production to a standstill, you'll the rig
got a half-dead refinery on your hands. And that means lost pr arts. G
duction time, maintenance or replacement costs, and misse ited S
delivery dates!

National Tube has 24 different ways to help you keep a refine
alive. Our 60 years of dealing with tubular problems has made bon
possible to develop 24 seamless steel pipe and tube analyses bon, ½
each designed for a specific set of refinery conditions such as e Cr, ½ M
posure, oxidation, acids, corrosion, high pressures, and eleva Cr, ½
temperatures. Other analyses are available in tubular form and Cr, ½ M
wide variety of high temperature problems are under study. Cr, 1 M
We also have a trained Mill Service Force available for field co Cr, ½
sultation. These men are ready to help you find the right allo Cr, 1 Mo
The w

For more data on advertised products, use Readers' Service Cards, last page.



dstill, you'll the right price, to meet your needs. So stop trouble before it
ans lost pr arts. Get complete details by writing National Tube Division,
and miss ited States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is registered trademark

ep a refine
has made
e analyses
s such as
and elevat
ar form and
er study.
for field co
e right all

Here are National Tube's two dozen different tube analyses:

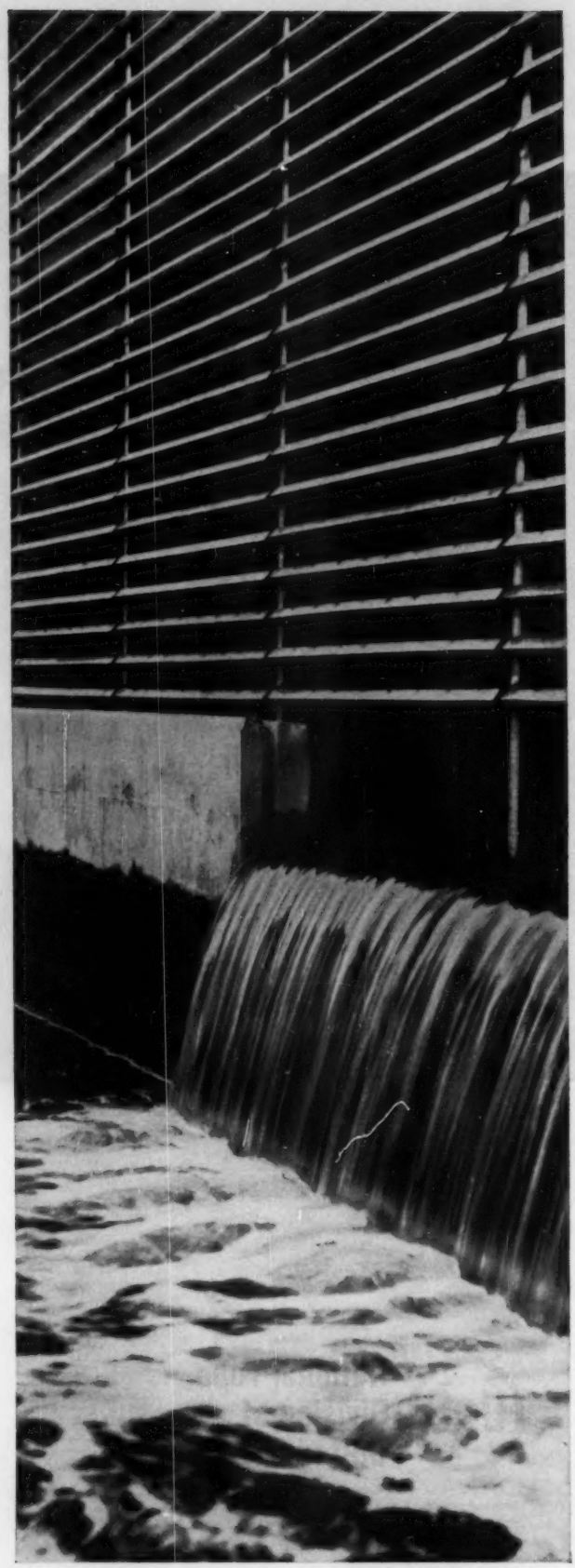
bon	5 Cr, ½ Mo	17 Cr
bon, ½ Mo	5 Cr, ½ Mo, 1½ Si	18-8
Cr, ½ Mo	7 Cr, ½ Mo	18-8 Ti
Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo
Cr, 1 Mo	9 Cr, 1 Mo	25-20
Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
Cr, 1 Mo	12 Cr, Al	5 Ni

The world's largest and most experienced manufacturer of tubular products

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division, United States Steel Export Company, New York

For more data on advertised products, use Readers' Service Cards, last page.



Wanted! 215,000,000,000 gallons of water per day!

Your process cooling towers may be doing a fulltime job now, but soon you'll have to work them overtime. By 1975, report authorities, industry *alone* will require 215,000,000,000 gallons of water per day!

To stand up to such intensive usage, towers should have the protection that only continuous L&N pH control automatically provides. L&N engineers treat each tower as an individual pH problem. Its control system is engineered on the basis of L&N's pH Controllability Analysis. This appraisal of the tower's "controllability factors" (flows, retentions, concentrations, etc.) tells us whether pH is actually controllable under existing tower conditions. If the answer is negative, the analysis highlights what must be done to *make* pH controllable.

The benefits of this unique L&N approach are significant. They include, in the words of an operator of two 200,000-gallon towers, ". . . conserving large amounts of make-up water, wood protection, prevention of carbonate scale, and more effective slime control." His report adds that "automatic pH control at both plants has been effective and satisfactory."

Write for Process Data Sheet 700(1), "L&N pH Control of Cooling Tower Water." You'll also receive our Controllability Analysis Questionnaire to complete and return, without obligation, for answers to your cooling tower pH problems. The address, Leeds & Northrup Co., 4923 Stenton Ave., Phila. 44, Pa.

LEEDS NORTHRUP
Instruments Automatic Controls . Furnaces

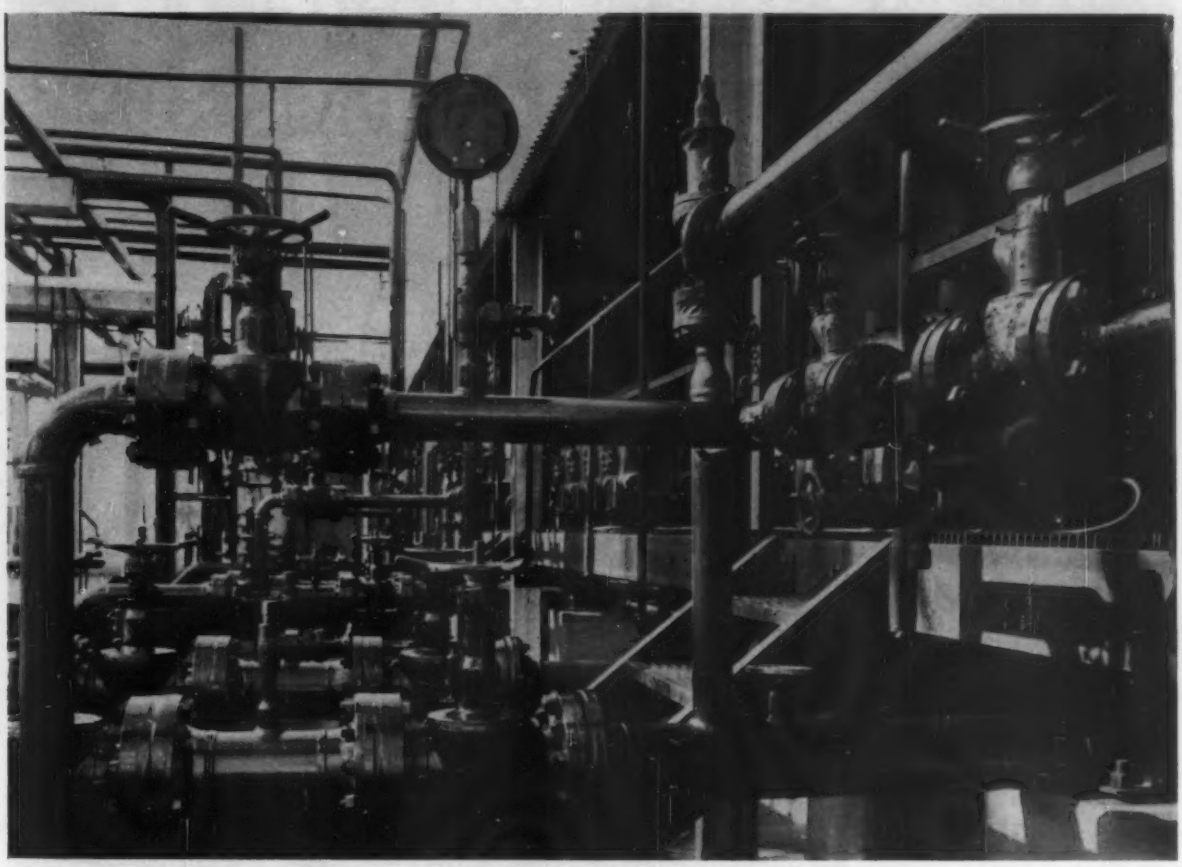
Photo courtesy J. F. Pritchard Co.

START

USING ORBIT FORGED STEEL VALVES IN YOUR PROCESS AREA FROM FORMATION TO FINISHED PRODUCT

There are no voids or cavities in the body or bonnet of an Orbit Forged Steel Valve where pressures can build up from trapped fluids or gases when the valve is either in open or closed position. Body and bonnet is all forged steel, vapor-tight construction.

Stem packing chamber has great depth and capacity for easier adjustment and longer life of the packing. Stem packing is pliable and adjustable and can be added to or adjusted while the valve is in service and under pressure.



Orbit Valves in Typical Platformer Service Handling Recycle Hydrogen Gas at Approximately 500 psig and 100° F.

WRITE FOR CATALOG 58-B

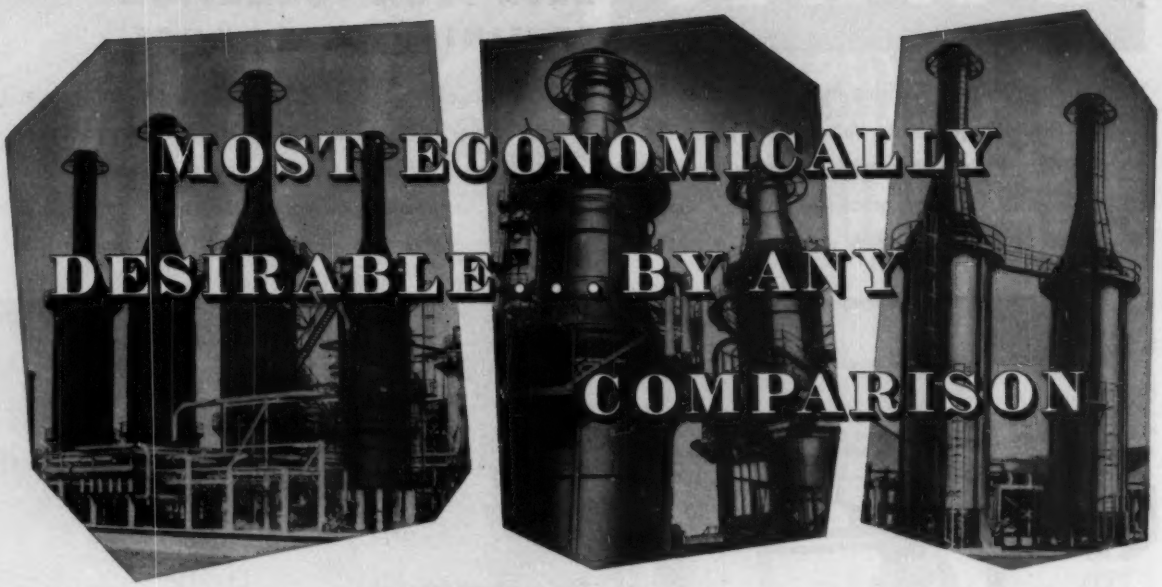
ORBIT VALVE COMPANY

PHONE LUther 4-4761 TWX TU 925
P. O. BOX 699 TULSA, OKLAHOMA

WAREHOUSES: HOUSTON, TEXAS, 407 Velasco, CApitol 8-6623, TWX HO 115; ODESSA, TEXAS, 402 West County Road, FEderal 7-2263, TWX ODESSA TEX 8706; LAFAYETTE, LOUISIANA, 3111 Cameron St., CEnter 4-3326; CASPER, WYOMING, 414 South Elm Street, Phone 2-1324; EDMONTON, ALBERTA, CANADA, 7119-104th St., Phone 391-283. WEST COAST REPRESENTATIVES: Charles Lowe Company, 383 Fourth Street, San Francisco, Calif.; Marshall E. Niedecker Company, 2785 Cherry Ave., Signal Hill, Calif. CANADIAN REPRESENTATIVES: T. R. Pickford & Company, Ltd., Calgary, Alberta, 309 7th Avenue West; Amherst 2-7371. EXPORT REPRESENTATIVE: New York 36, N. Y., 500 Fifth Avenue, BRyant 9-2236.

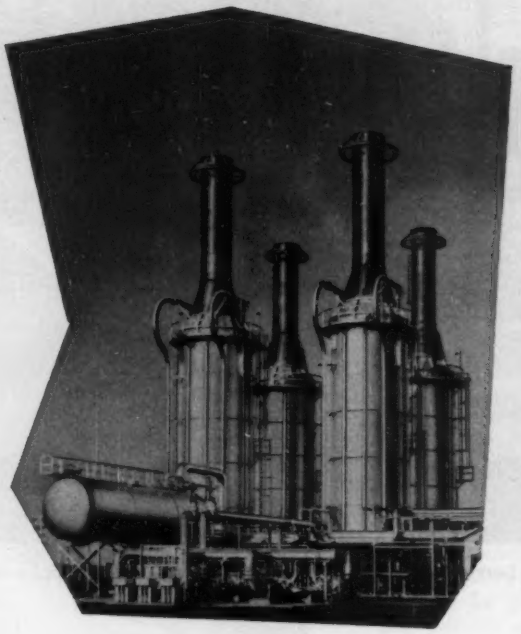
ORBIT VALVES ®

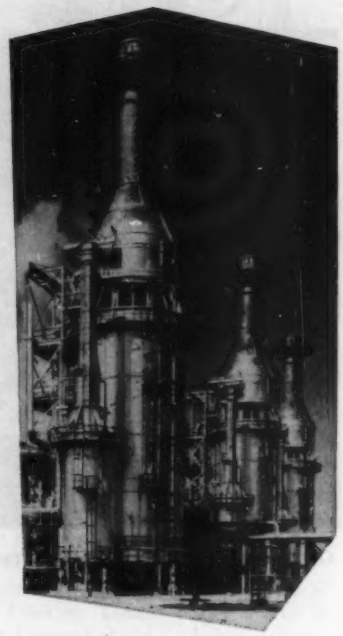
PETROCHEM-ISOFLOW FURNACES



MOST ECONOMICALLY DESIRABLE . . . BY ANY COMPARISON

in every country of the free world for every process heating requirement



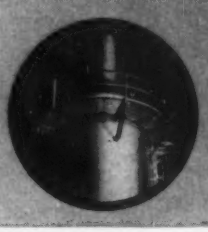


PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

REPRESENTATIVES: Faville-LeValley, Chicago • Flagg, Brackett & Durgin, Boston • D. D. Foster, Pittsburgh • William H. Mason, Tulsa • Lester Oberholtz, Los Angeles • Combustion & Power Equipment Ltd., Montreal and Toronto • Rawson-Houlihan Co., Houston • Rawson Co., Baton Rouge • Rittelmeyer, Atlanta • H. W. Severance, Prospect, Ky. • Turbex Equipment, Narberth, Pa. • G. M. Wallace, Denver, El Paso & Salt Lake City International Licensees and Representatives: Birwelco Ltd., Birmingham, England • Fujinagata Shipbuilding Ltd., Osaka, Japan • Heurtey Italiana, S.P.A., Milan, Italy • Petrochem G.M.B.H., Dusseldorf, Germany • SETEA S.A., Buenos Aires, Argentina • Societe Anonyme Heurtey, Paris, France • Societe Anonyme Belge Heurtey, Liege, Belgium



Now Permanent Concrete Buildings *Erected in Hours!*

DESIGN—Rackle provides professional assistance in building design and all phases of engineering.

MANUFACTURE—4000 to 5000 PSI lightweight Haydite concrete is conventionally reinforced and/or prestressed by Swiss-patented BBR system. Strict production and laboratory control insures positive strength in Rackle members.

DELIVERY—Rackle trucks deliver structural components to jobsite as soon as the foundation is poured.

ERECTION—Units are put into place as quickly as they are delivered. Columns are set first. Then beams. Finally channel roof deck. Small buildings can be set in 8 hours; a 30,000 sq. ft. warehouse in 40 to 60 hours.

FINISHING—Six inch thick pre-cast wall panels with plain or textured surfaces can be installed rapidly, or you can use any other architectural treatment you prefer.

From design to finished product, Rackle provides a complete concrete building engineered to individual specifications with speed and economy.

Rackle's new engineering and production technique makes *extra speedy* construction possible with permanent, maintenance-free concrete.

Engineered and cast to individual specifications at our Houston plant, Rackle structural members are trucked to your building site and erected in a matter of hours.

Initial cost is surprisingly low because of speed of construction, and when you build with concrete you continue to save for many years because concrete requires little or no maintenance and insurance rates are lower, too.

Write or call today for literature on building with Rackle.

THE RACKLE COMPANY OF TEXAS

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Serving the Texas Gulf Coast Only

Manufacturers of quality concrete products since 1870 . . . a wholly owned subsidiary of the Geo-Rackle and Sons Co., Cleveland, Ohio.

For more data on advertised products, use Readers' Service Cards, last page.

take NEWTHERM on test!

Test its STRENGTH

NEWTHERM is unusually strong and rigid—a feature of special importance in the larger, more vulnerable sections. Put a sample section or slab on part of your plant and *prove for yourself* its outstanding ability to withstand impact and water damage. See how it withstands rough handling in transit and erection, minimising breakage in shipment and erection by unskilled labour at the most remote sites.

Test its MOISTURE RESISTANCE

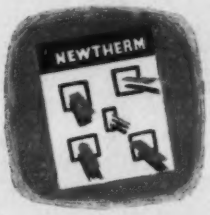
Even totally immersed in water, NEWTHERM retains much of its strength and rigidity. It does not become deformed when in contact with water, thus work-in-progress need not be covered. Especially on contracts where weather conditions would delay the application of insulation – NEWTHERM is the material to use.

Test its LIGHTNESS

Unusually light for such a high-efficiency material, NEWTHERM compares favourably in this respect with other insulants far inferior in strength. That means easier handling and fewer breakages—even the largest section is easily carried in one hand.

Test its EASE OF APPLICATION

Undoubtedly, NEWTHERM is one of the easiest of materials to apply. It is supplied in plastic form and in a wide range of standard-sized sections and slabs, smoothly finished and straight edged for immediate fitting. The finished job is very neat, with minimum joints, and appliers particularly appreciate the handleability of the material – especially in difficult situations.



READ ALL ABOUT NEWTHERM

in a specially prepared booklet. Sizes, compressive strength, thermal conductivity,—this and much more useful information can be on file if you write for your copy now, to the sole manufacturers Newalls Insulation Co. Ltd.

NEWALLS (Reg'd Brand)

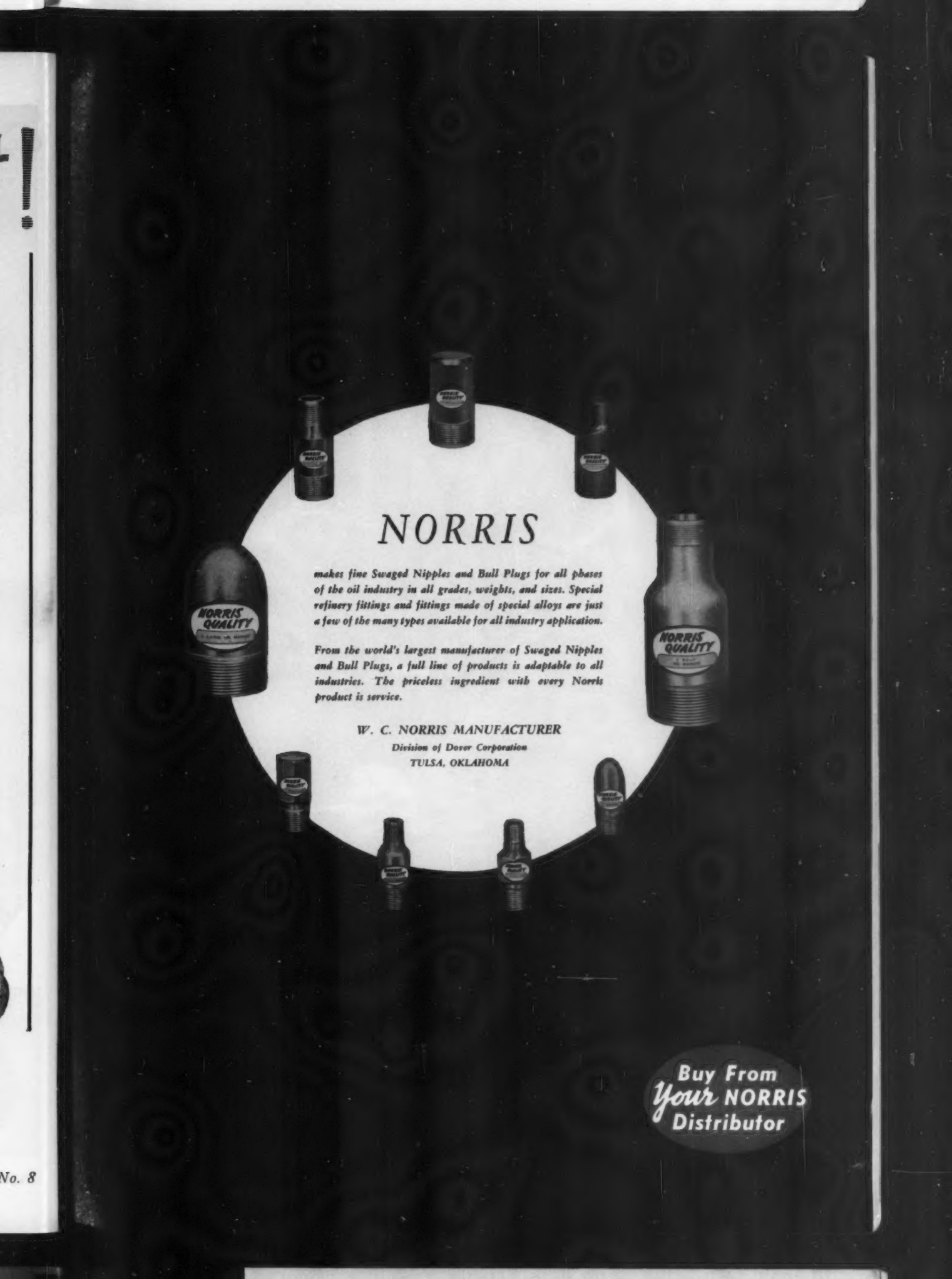
***NEWTHERM** calcium silicate insulation*

. . . for temperatures up to 1400°F.

NEWALLS INSULATION CO. LTD.

Head Office: WASHINGTON, CO. DURHAM, ENGLAND.
A member of the TURNER & NEWALL ORGANISATION
Offices & Depots at: LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL & CARDIFF.
Agents and Vendors in most markets abroad.

For more data on advertised products, use Readers' Service Cards, last page.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makes fine Swaged Nipples and Bull Plugs for all phases of the oil industry in all grades, weights, and sizes. Special refinery fittings and fittings made of special alloys are just a few of the many types available for all industry application.
From the world's largest manufacturer of Swaged Nipples and Bull Plugs, a full line of products is adaptable to all industries. The priceless ingredient with every Norris product is service.
W. C. NORRIS MANUFACTURER
Division of Dover Corporation
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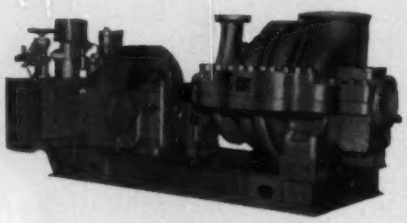
NORRIS QUALITY
Buy From Your NORRIS Distributor

Background: *Compressing isobutane in refrigeration-system of alkylation plant of Petro-Tex Chemical Corp.* **Foreground:** *Cutaway of high-pressure seal of Cooper-Bessemer Type RD Centrifugal Compressor.*

Matched to your needs... *A wide range of types and sizes of Cooper-Bessemer Centrifugal Compressors are available to assure optimum performance on your processing or air supply application.*



Undivided responsibility... *We can engineer the entire compressor installation, including drive and controls.* *Cooper-Bessemer En-Tronic® Controls* provide any degree of automation.

John Fullemann, *Chief Turboproduct Design Engineer, right, and* Kenneth Stevenson, *Turboproduct Designer, The Cooper-Bessemer Corporation, discuss...*

How reliable Cooper-Bessemer Centrifugal Compressors aid 'round-the-clock processing

For example, here's the picture at Petro-Tex Chemical Corp., Houston: The entire sulfuric acid alkylation plant banks on the dependable performance of the Cooper-Bessemer Type RD Centrifugal Compressor which handles isobutane for refrigeration. This unit operates on a continuous, 24-hour basis, handling 11,125 cfm and boosting pressure from 16.2 to 98 psia. Its constant availability is a must.

Of course, many things go into Cooper-Bessemer centrifugals to assure this kind of reliability. For example, take the two-sleeve oil film type seals shown in the illustration. This Cooper-Bessemer design is capable of sealing against pressures of more than 1000 psi, for utmost dependability in processing service.

Bear in mind, too, that the performance of Cooper-Bessemer equipment is backed by an unsurpassed service organization to help protect your plant investment and assure optimum operating economy. For further information, call our nearest office.

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PROGRESS, TOO, HAS ITS GOLDEN RULE...

It's the *teamwork* of men capable of producing progress—refiners and Cyanamid chemists.

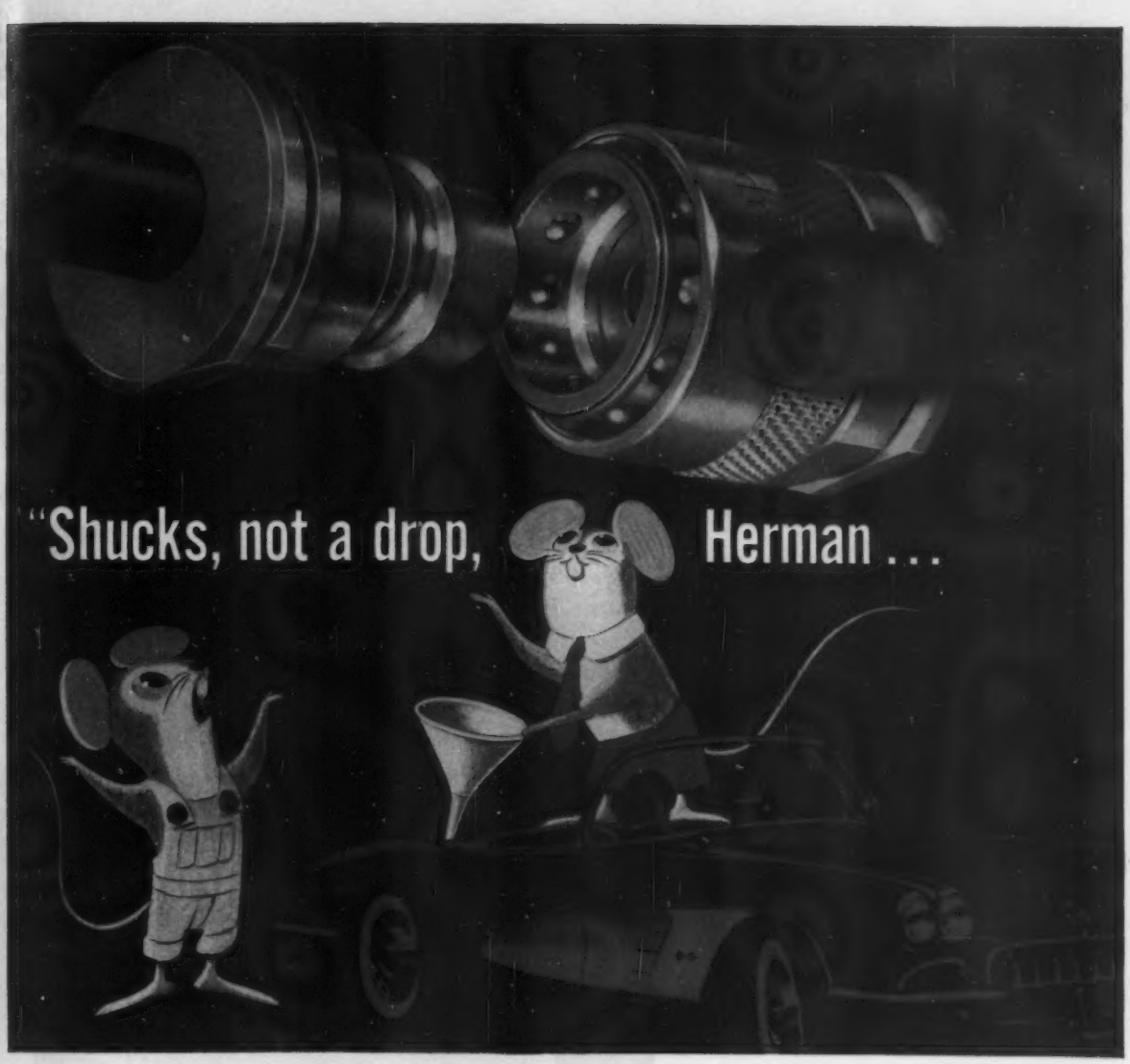
This teamwork has produced concrete benefits. It helped bring the development of one of the first synthetic fluid cracking catalysts. It helped produce the first fully regenerative platinum reforming catalyst. It can help you meet the almost-relentless demands for ever superior fuels.

Behind Cyanamid's service as a major catalyst producer are its unlimited resources as a major chemical producer. Cyanamid's man with the golden rule can place at your disposal vast research and development facilities.

Basic in Catalyst Chemistry

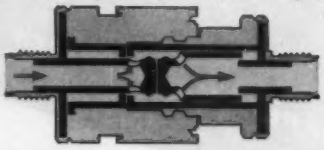
CYANAMID

AMERICAN CYANAMID COMPANY
REFINERY CHEMICALS DEPARTMENT
30 Rockefeller Plaza, New York 20, N. Y.

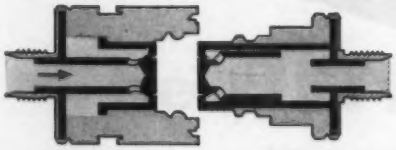


. . . it's a no-spill valved coupling by Snap-Tite!"

To use Snap-Tite Valved Coupling:



CONNECT—Full flow instantly



DISCONNECT—Stop flow instantly

The 15 Series valved coupling automatically snaps off the flow of the most volatile fluids when disconnected—with no leakage.

Snap-Tite's 15 Series valved coupling contains valves in both sections. Thus, the only fluid lost is that which clings to the outer metal surfaces. This coupling meets military specifications and can be used with fuels and other fluids to 3000 psi working pressure and 400°F. Sizes: 1/4", 1/2", 3/4", 1" in 6061T6 aluminum anodized: 3/8" in steel (electroless nickel plated), and 6061T6 aluminum.

Snap-Tite can provide the right valved coupling—with quick off-on action wherever coupling or shut-off is required—for most any use, most any fluid.

For more information, write for Snap-Tite Catalog #15. Snap-Tite representatives in all principal cities.

★ Snap-Tite

ST-59-03

UNION CITY 12, PA.

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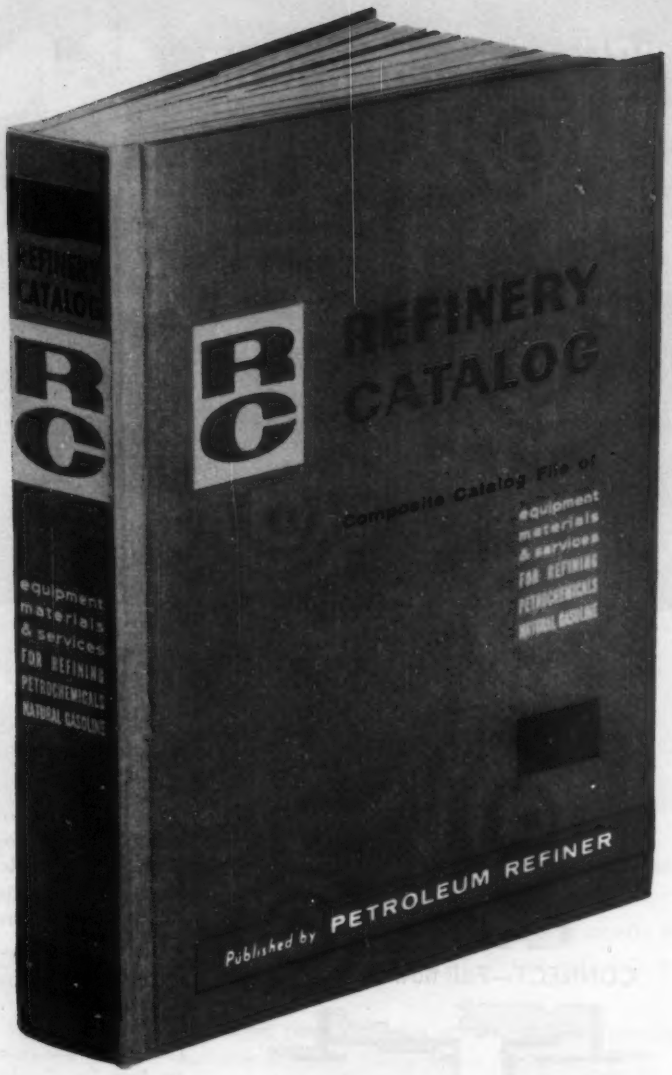
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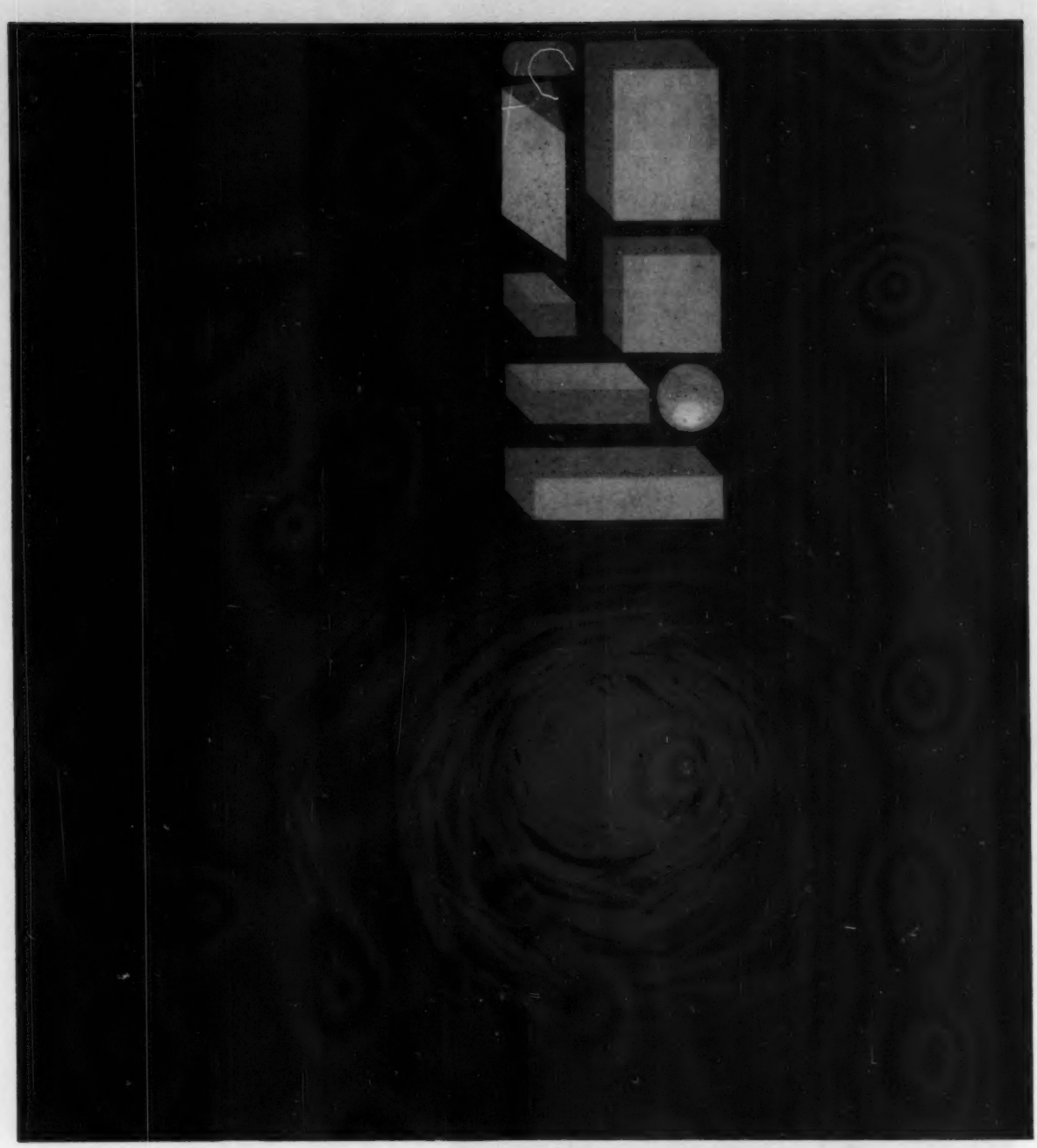


Don't let rising process heats ruin your refractories

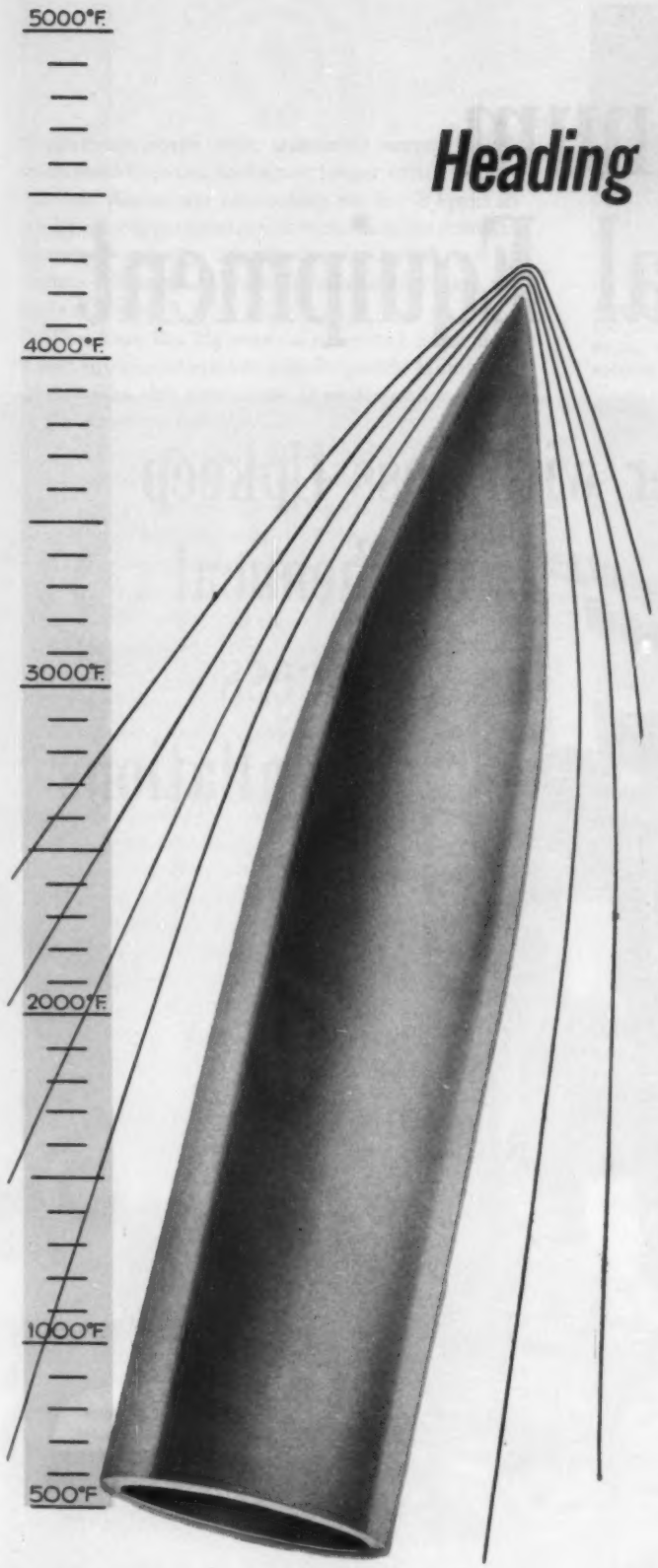
...or your profits... *mix imagination with Alcoa Aluminas*

The steady increase in general process temperatures poses no problem at all for refractories fortified with ALCOA® Aluminas. Their refractoriness rises in direct proportion to the amount of alumina in their composition. These high-purity aluminum oxides also add greatly to strength and stability under load at elevated temperatures. And high-alumina refractories are chemically stable, immune to both oxidizing and reducing atmospheres. They offer just one more illustration of the many good reasons why makers and users of a variety of products have found it pays to *mix imagination and engineering with Alcoa Aluminas . . . to make an old product better or a new product possible.* Discover what ALCOA Aluminas can do for your own product or process. Outline your requirements in a letter to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 708-H Alcoa Building, Pittsburgh 19, Pennsylvania.

For finer products...let Alcoa add new dimension to your creative thinking!

ALCOA CHEMICALS

For exciting drama, watch "Alcoa Theatre," alternate Mondays, NBC-TV, and "Alcoa Presents," every Tuesday, ABC-TV.



Heading for the unknown?

Check your processing requirements against Norton Fused Zirconia

You can't predict tomorrow's processing requirements. However, you can be prepared to meet many of them more efficiently and economically . . . with Norton *Lime-Stabilized* Fused Zirconia.

Consider Its Unusual Characteristics

Extremely high melting point (4,620°F) coupled with a lower thermal conductivity than standard dense refractories • Excellent resistance to thermal shock and abrasion • Not wet by most metals • Moderate electrical insulator at low temperatures and conductor above 2,200°F • Good stability in either oxidizing or reducing atmospheres.

Consider Its Many Applications

As potential material for use in missiles and reaction motors • As a support for firing highly-reactive titanates • As lining for furnaces containing high temperature gaseous reactions • For furnace parts and linings used in the metals industry • As lining and packing media for high temperature air heaters and heat exchangers • For many other critical processes.

Chances are you can improve both your processing and your production economy with this rugged, versatile material. Let a Norton Sales Engineer help. He's well qualified to discuss your precise requirements. Write to NORTON COMPANY, Refractories Division, 467 New Bond Street, Worcester 6, Mass.

Note: Norton *Lime-Free* Fused Zirconia is also available for the manufacture of refractories, as a source material for zirconium for chemicals and metals, or as an opacifier for glazes and enamels.

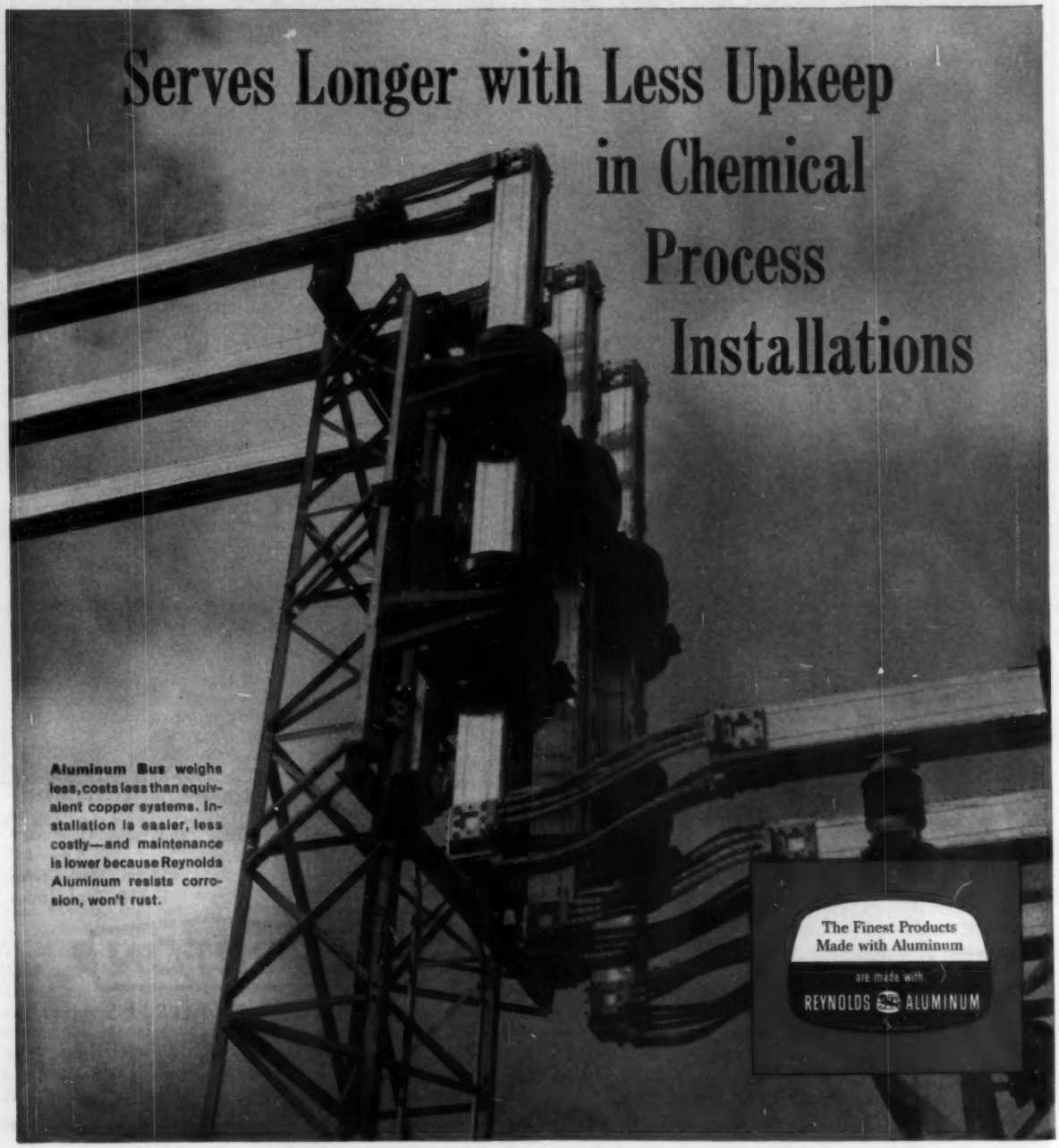
Melting Point	4,620°F
Maximum Usable Temperature	4,450°F
Chemical Nature	Stable
Electrical Resistivity	High Temperature Conductor
True Specific Gravity	5.6 — 5.7
Two Grain Types	Hard Dense Grains Bubble-Type Grains

NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

Making better products . . . to make your products better

NORTON PRODUCTS Abrasives • Grinding Wheels • Grinding Machines • Refractories • Electrochemicals — BEAR-MANNING DIVISION Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

Aluminum Electrical Equipment


Serves Longer with Less Upkeep in Chemical Process Installations
Aluminum Bus weighs less, costs less than equivalent copper systems. Installation is easier, less costly—and maintenance is lower because Reynolds Aluminum resists corrosion, won't rust.
The Finest Products Made with Aluminum
are made with
REYNOLDS ALUMINUM

Equipment made with aluminum serves longer with less attention, looks new longer with less protection. Aluminum conductors are much lower in cost than copper conductors with the same current-carrying capacity. Aluminum won't rust, and it resists corrosion. It's the *lowest-cost* corrosion resistant metal.

These are the big reasons more and more electrical equipment is made with Reynolds Aluminum —and why this equipment is preferred for chemical processing installations.

And there are other reasons, just as important. Equipment and conductors made with aluminum are easier to handle, easier to install. Aluminum is about one-third the weight of steel, or copper.

Aluminum's electrical properties can improve the performance of your electrical systems, too. Aluminum conductors often carry more current, and have excellent thermal conductivity, as well. Voltage drop may be lower with aluminum, and aluminum is non-magnetic, non-sparking.

For an electrical system or electrical equipment that will perform better, require less maintenance, and cost to install, specify conductors and equipment made with Reynolds Aluminum for the following applications . . . substations (structural members and conductors), wire and cable, cable trays and interlocked armored cable (sheathing and conductor), bus duct systems, bus bar or tube (available silver plated or bare), rigid conduit, metal enclosed switch gear. And you'll find tough, corrosion-resistant Reynolds Aluminum can cut your costs and improve plant appearance in a wide range of chemical and petroleum processing applications: jacketing, heat exchangers, tanks and vessels, piping, even drilling equipment.

Contact your local Reynolds branch office for details, or write *Reynolds Metals Company, P.O. Box 2346-CT, Richmond 18, Virginia.*

Aluminum Rigid Conduit is now competitive with steel in initial cost, and lower in installed cost. 10 ft. length, 3 in. size, weighs just 27 lbs., compared with 69 lbs. for steel. It's non-magnetic, non-sparking, non-rusting.

Aluminum Structurals are ideal for chemical processing substations. Their light weight cuts installation time, their corrosion-resistance adds years of service.

Interlocked Armor Cables and Cable Trays made with aluminum can be installed much faster than equivalent steel systems. Corrosion-resistant, non-magnetic, as well.

REYNOLDS ALUMINUM

Write today for free brochures on Reynolds Aluminum in electrical applications.

Watch Reynolds TV show **"WALT DISNEY PRESENTS"** every week on **ABC-TV**

Reynolds Metals Company
P.O. Box 2346-CT, Richmond 18, Virginia

Gentlemen: Please send me the brochures I have checked below.

- ☐ "Reynolds Aluminum in the Electrical Industry"
- ☐ "Silver Plated Bus Bar"
- ☐ "Aluminum Rigid Conduit"
- ☐ "5005 All Aluminum Conductor"

Name_____

Firm_____

Address_____

City_____ State_____

another
TRETOLITE SERVICE
report

BEFORE KONTOL! *Here's what a tube bundle looked like in one of the heat exchangers of an Ohio refinery — after just 94 days of service. A* KONTOL *Protection Program has since trebled tube life, upped heat exchange efficiency by more than six million BTU's per hour!*

KONTOL* CORROSION INHIBITOR TRIPLES TUBE-BUNDLE LIFE AT OHIO REFINERY

Also saves $96.00 per day on increased BTU's . . . The effectiveness of KONTOL* protection against corrosion and fouling in tube bundles was dramatically demonstrated in the heat exchange equipment of the crude unit at a large refinery in Ohio.

Since the inauguration of a regular KONTOL Corrosion Inhibitor program, the tube bundle life period has been increased by approximately 3 times the bundle life prior to the use of KONTOL.

KONTOL'S DETERGENT ACTION ADDS DOLLAR-BONUS TO OPERATION

The detergent action of KONTOL Corrosion Inhibitor provided a *plus* benefit for the refinery. A cleaner operation has resulted in the gain of an additional 6,000,000 BTU's per hour—or a savings of about $96.00 per day.

THERE'S A KONTOL PRODUCT FOR YOUR CORROSION PROBLEM

The KONTOL product used in this case was based on a careful study of the refinery's specific needs. The Tretolite Company developed and pioneered the application of organic corrosion inhibitors throughout the petroleum industry. No other organization has Tretolite's wealth of experience and know-how in the manufacture and use of these products. This background (Tretolite corrosion engineers, laboratory and research facilities) is always available to you—to help solve your particular corrosion problems. A call will bring you this service—at no obligation.

*KONTOL *is a registered trademark of Petrolite Corporation.*

KR-59-1

PETROLITE
CORPORATION

TRETOLITE COMPANY
DIVISIONS
369 Marshall Avenue, Saint Louis 19, Missouri
5115 Telegraph Road, Los Angeles 22, California

CANADA: Petrolite Corporation of Canada, Limited, 309 Alexandra Bldg., Edmonton, Alberta

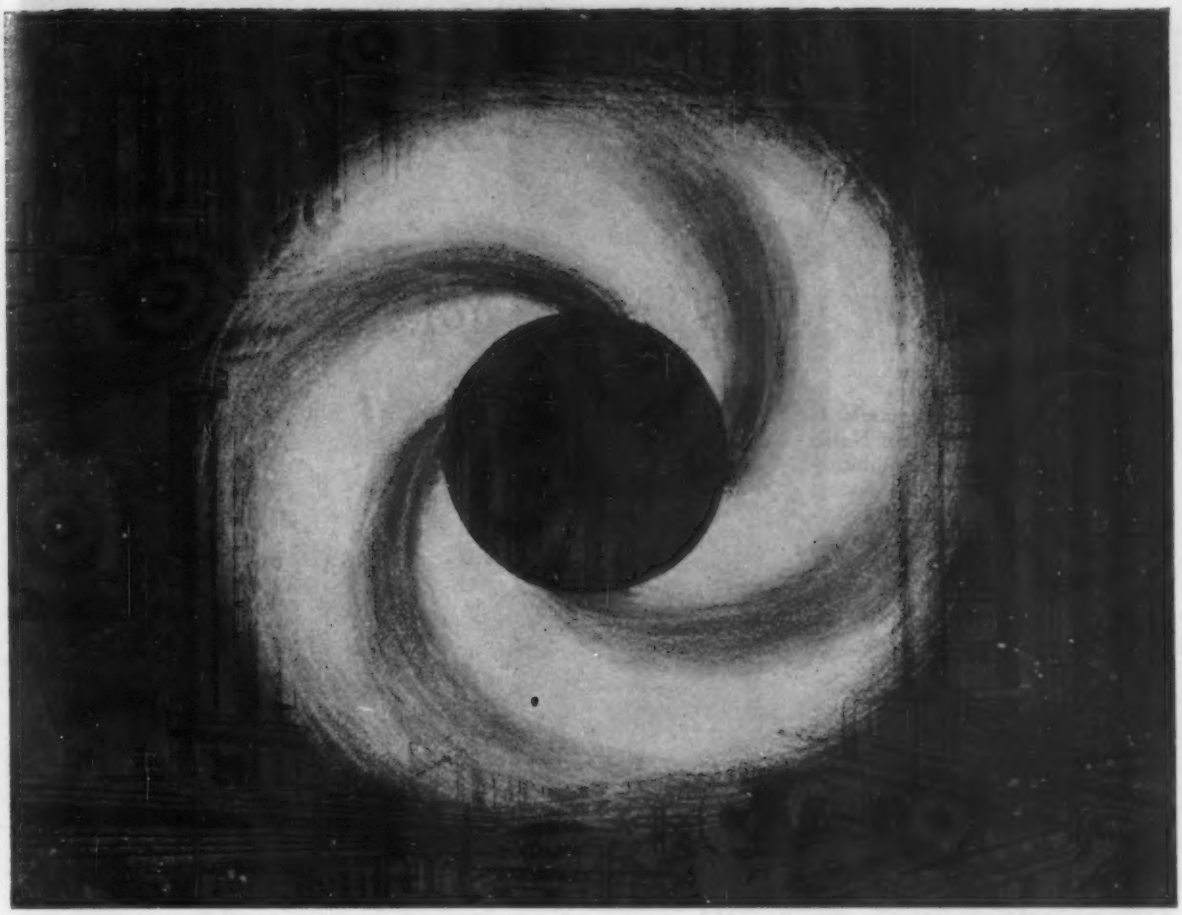
COLOMBIA: South American Petrolite Corporation, Calle 19, No. 7-30, Office 807, Bogota

ENGLAND: Petrolite Limited, 46 Mount Street, London W. 1.

VENEZUELA: South American Petrolite Corporation, Hotel Avila, Caracas

REPRESENTATIVES

BRAZIL: WERCO, Ltda., Rua General Gurjao 326, Rio de Janeiro
GERMANY: H. Costenoble, Guiollettstrasse 47, Frankfort, a.M.
ITALY: NYMCO S.p.A. 9, Lungotevere A. da Brescia, Rome
JAPAN: Maruwa Bussan KK, No. 3, 2-Chome, Kyobashi, Chuo-Ku, Tokyo
KUWAIT: F. N. Dahdah, Box 1713, Al Kuwait
MEXICO: R. E. Power, Sierra de Mijes, No. 125, Mexico, D. F.
NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
PERU: International Gas Lift Company, Apartado 71, Talara
TRINIDAD: Neal and Massy, Ltd., Port of Spain, P.O. Box 544



BROWN & ROOT

HAS DESIGNED AND INSTALLED MORE GAS TURBINE HORSEPOWER THAN ANY OTHER ENGINEER-CONSTRUCTOR

Of the total installations in the world, one out of every three gas turbine compressor drives used in the petroleum industry has been designed by Brown & Root. Today, over 1,735,000 horsepower of the relatively new gas turbine drive is at work in various branches of the industry.

With its own forces, Brown & Root has installed 75 per cent of the units it has designed, and is familiar with — and has used components of — all U. S. and many foreign gas turbine manufacturers.

In the over-all field of gas compression and power generation, Brown & Root has designed and installed a total of 1,620,000 horsepower.

If you are planning a gas turbine installation — anywhere in the world — your inquiry will receive our prompt attention . . . with no obligation.

BROWN & ROOT, INC.

Engineers · Constructors

POST OFFICE BOX 3, HOUSTON 1, TEXAS

NEW YORK, NEW YORK · WASHINGTON, D. C. · PANAMA CITY, PANAMA · EDMONTON, ALBERTA
SAO PAULO, BRAZIL · CARACAS, VENEZUELA · MARACAIBO, VENEZUELA · CABLE ADDRESS -- BROWNBILT

For more data on advertised products, use Readers' Service Cards, last page.

Instrument Monitors Corrosion Rates While Equipment Stays on Line

Fastest Known Corrosion Rate Measurement

The *Corrosometer* is its name. It proves the effectiveness of Nalco refinery stream corrosion inhibitors . . . in a hurry. It is the fastest known method of determining corrosion rates in operating equipment; manufactured by Crest Instrument Co. under license from Standard Oil Company (Indiana), and distributed worldwide, by Nalco.

Corrosometer readings are taken quickly and accurately, indoors or out. Instrument leads are attached to probes mounted in corrosion trouble spots. One instrument serves virtually any number of probes.

Coupons, Inspections are Slower

Determining corrosion rates by loss-in-weight methods, using coupons inserted in lines, is a much slower process. Valuable in determining average corrosion rates, it lacks the speed that enables the Corrosometer to reveal immediately any change in corrosion rate caused by process variations. Nalco Representatives, as well as Nalco Corrosion Inhibitor customers and prospects, welcome the speed with which the Corrosometer delivers accurate corrosion rate readings as a real contribution to time and money-saving establishment of good corrosion control practices.

Corrosometer Can Show Day-to-Day Corrosion Rates in System

Readings taken with the Corrosometer show the corrosion rate in the system for a predetermined interval of time. The interval may be as long as desired—or as short as a day or less. Thus checks of Nalco treatment effectiveness, as well as prompt detection of unexpected increases in corrosivity, are practical and accurate with the Corrosometer.

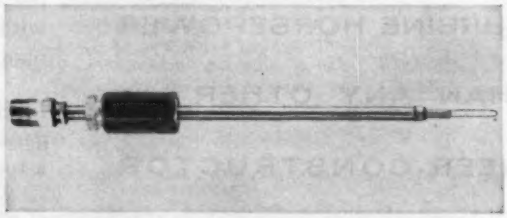
How Corrosometer Works . . .

Utilizing the Kelvin electrical bridge circuit, the Corrosometer compares resistances of two similar probes: one protected from corrosion, the other directly in contact with the liquid or gas in the equipment under test. Corrosion of the unprotected probe increases its electrical resistance, and the difference between probe resistances is directly convertible to corrosion-rate readings of high accuracy.

Retractable probes, for easy replacement without shutting down the system, and probes for high temperature and high pressure systems make the Corrosometer a valuable tool in checking Nalco Results in all types of corrosion-prone equipment.

Your Nalco Representative can give you full details on both the Corrosometer and Nalco corrosion inhibitors. Call him today — or write for descriptive literature.

Refinery Corrosion Probe



Retractable probe can be installed through a gate valve; replaced quickly without taking equipment off line.

National Aluminate Corporation is now

NALCO CHEMICAL COMPANY

6216 West 66th Place • Chicago 38, Illinois

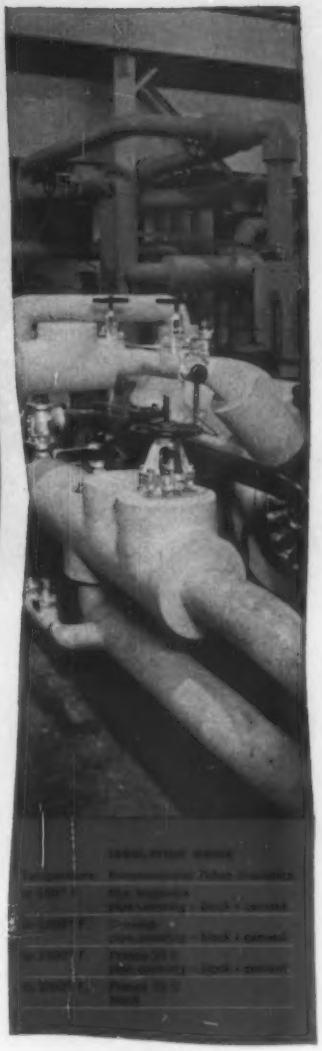
Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany

In Canada—Alchem Limited, Burlington, Ontario

Nalco® **Serving Industry through Practical Applied Science**

Nalco CHEMICALS

Nalco CHEMICALS



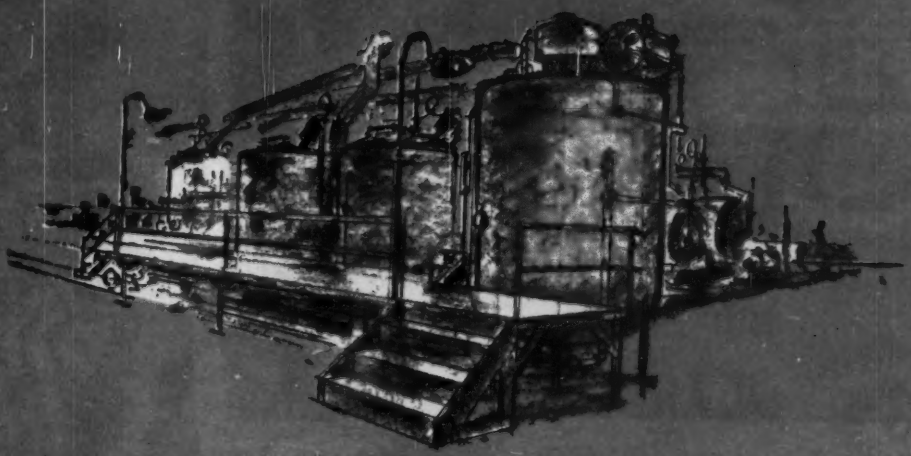
Name your temperature. A performance-proved Pabco pipe or block insulation will maintain it at economical levels up to 1900° F. With Pabco Caltemp, 85% Magnesia, or Prasco Insulations, heat losses are reduced to an absolute minimum . . . finest performance assured. For data on technical advantages, case histories, or engineering consultation . . . write . . . or contact one of Pabco's insulation engineers.

PABCO INDUSTRIAL INSULATIONS DIVISION

Fibreboard Paper Products Corporation • San Francisco 19 • Chicago 54 • Houston 4 • New York 16 • Los Angeles

High pressure processing . . . including Hydrogenation

Truland announces
the installation of
Hydrogenation and Autoclave
reaction facilities
for
high pressure operations.



May we serve you?
Your inquiry will be
treated in confidence.

Send for new booklet
which describes our operation

TRULAND CHEMICAL COMPANY
EAST RUTHERFORD, NEW JERSEY

Division of **THE TRUBEK LABORATORIES**

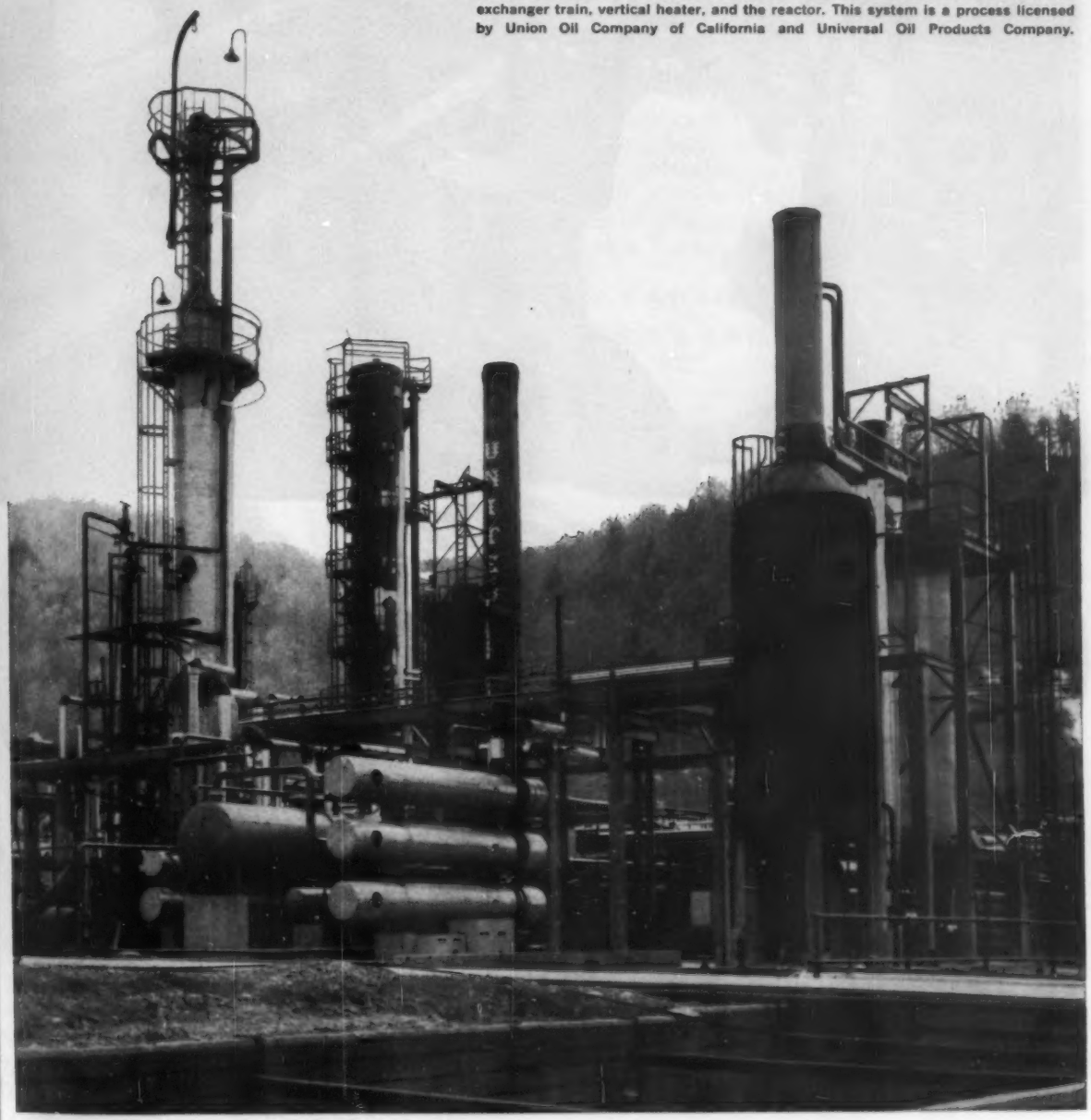
TRULAND

United Refining keeps expanding—first Unifiner in 1953, second in 1959—both designed by Blaw-Knox.

Now on stream: a new hydrogen treating system at United Refining Company's Warren, Pennsylvania, refinery. The system upgrades naphtha used as feed stock for catalytic reforming. The Unifiner, together with modifications Blaw-Knox made to the catalytic reformer, increases output of high octane gasoline. United Refining and Blaw-Knox worked together to install the *first* application of this process in 1953. Since then, Blaw-Knox has designed eight other hydrogen treating units with capacities ranging up to 15,000 barrels a day. Process pioneering requires a fresh outlook and technical skill found at Blaw-Knox. For details, contact Blaw-Knox headquarters in Pittsburgh, Pennsylvania. Branch offices in New York; Haddon Heights, New Jersey; Washington, D.C.; Birmingham; Chicago; and San Francisco. *Plant builders for industry . . .*

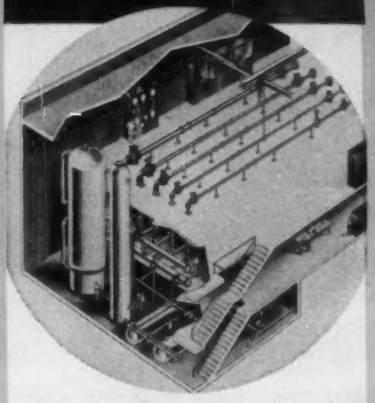
BLAW-KNOX

Unifining system comprises stripping tower (left), horizontal flasher drum and heat exchanger train, vertical heater, and the reactor. This system is a process licensed by Union Oil Company of California and Universal Oil Products Company.



The largest laboratory of

Flowmeters and manometers are just two types of precision equipment used for accurate measurement in this unique laboratory.

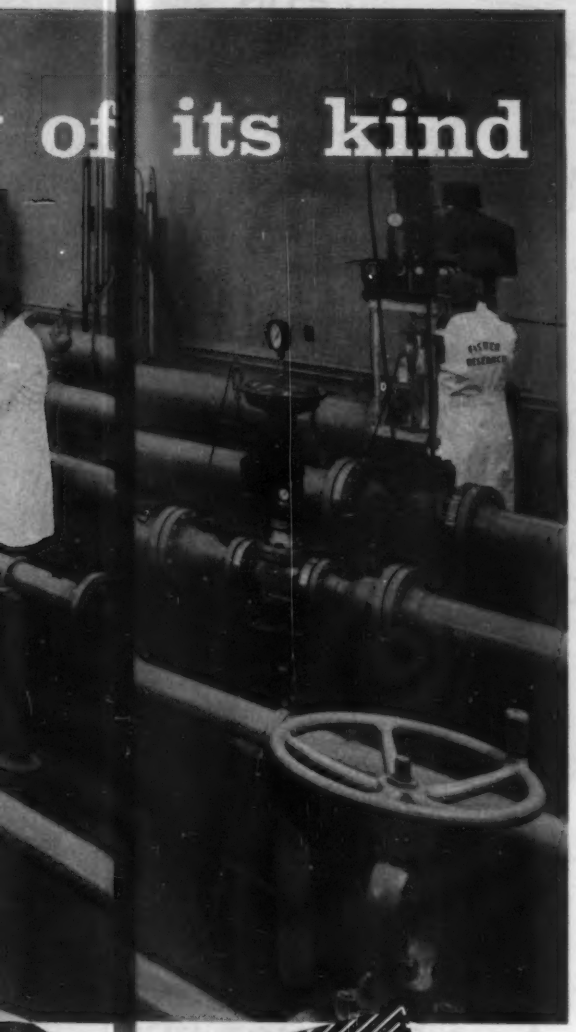


Three full stories are devoted to testing and proving the quality of all Fisher equipment.

A Fisher engineer obtaining frequency response data of Fisher equipment under test on an oscillograph.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD... CHANCES ARE IT'S CONTROLLED BY...

# of its kind in the world



where research engineers develop and perfect the quality of Fisher products

THIS is a remarkable facility. It's the nerve center of a 3-story laboratory built to duplicate every conceivable field condition under which any Fisher product might operate. There's no other like it, anywhere. The engineers shown are keeping keen observation on the operating characteristics of such Fisher equipment as pressure regulators, liquid level controls, diaphragm control valves . . . plus many other types. There are literally hundreds of these complex and abnormally rigid tests which Fisher controls are subjected to before they are released to the user.

QUICK FACTS ABOUT THE FISHER LABORATORY

- It is equipped with vessels capable of storage pressures up to 2500 psig. These vessels discharge into five flow metering lines ranging in size from 4 inches to 12 inches.
- It is possible to test with either air or water at 400 psig pressure. One 4-inch line is capable of 2500 psig pressure for air or water testing.
- All flows are metered with orifice plates and differential manometers. Liquid flows can be metered up to 6000 GPM and gas flows up to 7,000,000 SCFH.
- Actual flow test curves are recorded on each Fisher valve design. This gives a visual record of the operating characteristics of each piece of Fisher equipment and proves that its performance in the line will precisely match published data.
- It is an approved laboratory for determining official ASME capacity ratings on safety and relief valves used on unfired pressure vessels.

The end result of these combined facilities and constant vigilance is the building and maintenance of user confidence . . . so that when an instrument man says "put a Fisher in the line" he knows that it will perform as promised and guaranteed.

Send for Bulletin AL-8

This comprehensive booklet contains valve sizing and capacity charts obtained from thousands of actual laboratory flow tests for all Fisher body types and inner valve styles.

FISHER GOVERNOR COMPANY
Marshalltown, Iowa / Woodstock, Ontario / London, England
BUTTERFLY VALVE DIVISION: CONTINENTAL EQUIPMENT CO., CORAOPOLIS, PENNSYLVANIA

FISHER® Controls
SINCE 1880

For more data on advertised products, use Readers' Service Cards, last page.

AMOCO CHEMICALS—A NEW RESOURCE

Five AMOCO Additive Product Bulletins to help you

Here are five informative bulletins that give technical data helpful in evaluating AMOCO Additives. Bulletins document with test data and comparative illustrations, the performance of motor oils and gasolines containing AMOCO Additives. Typical physical and chemical properties of the additives are included. Technical service by experienced petroleum additive engineers, to assist you in the use of AMOCO Additives, is also available.

AMOCO 193 INHIBITOR

Gives information on this multi-functional zinc dithiophosphate motor oil additive which inhibits oil oxidation, protects bearings from corrosion, and prevents excessive wear of critical engine parts.

AMOCO 200 SERIES DETERGENT-INHIBITOR ADDITIVES

Data are given on the use of a number of the outstanding detergent-inhibitor additives of this series in making motor oils. All are combinations of Amoco's unique barium detergent and zinc dialkyl dithiophosphate inhibitor.

AMOCO 600 VISCOSITY INDEX IMPROVER

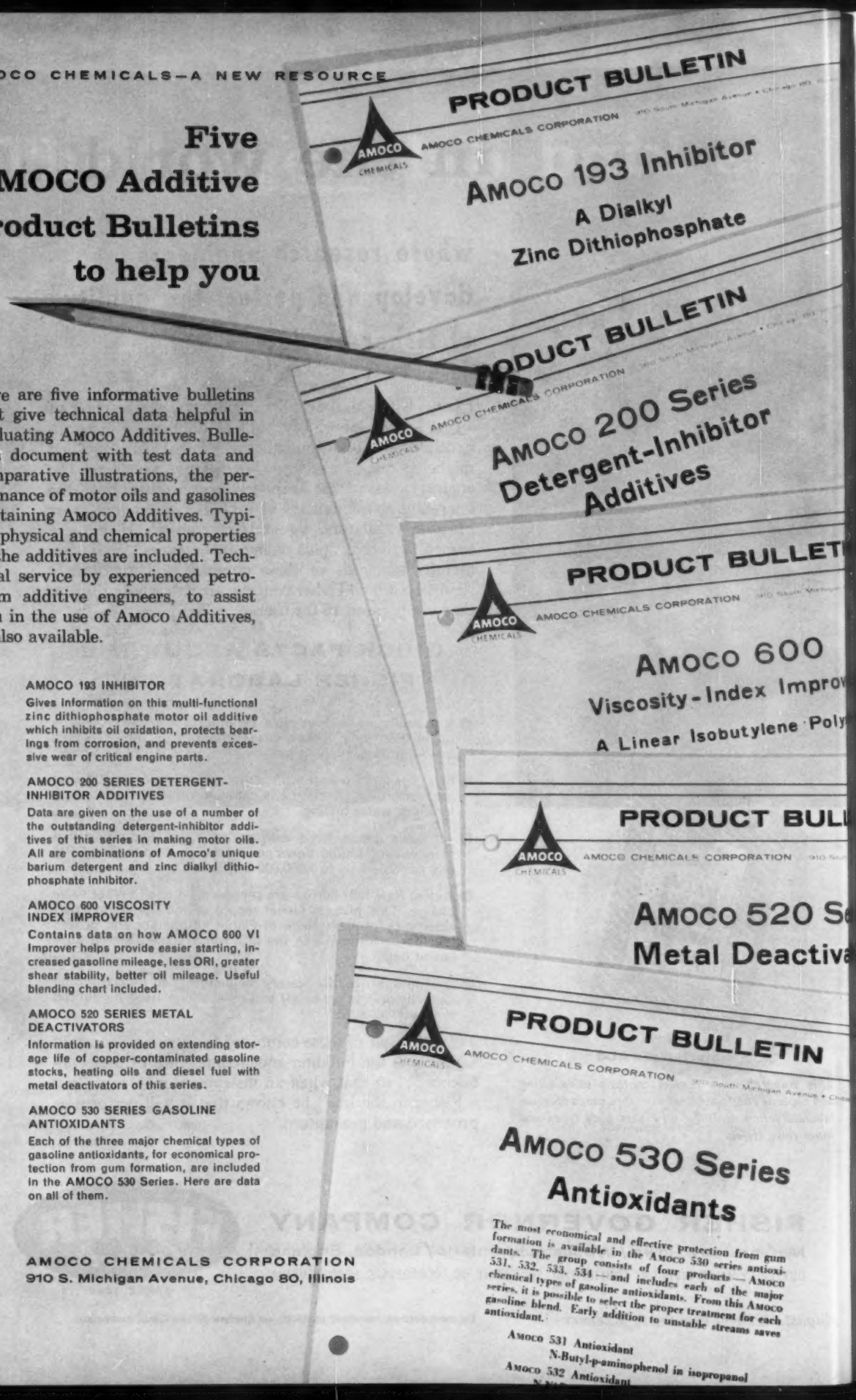
Contains data on how AMOCO 600 VI Improver helps provide easier starting, increased gasoline mileage, less ORI, greater shear stability, better oil mileage. Useful blending chart included.

AMOCO 520 SERIES METAL DEACTIVATORS

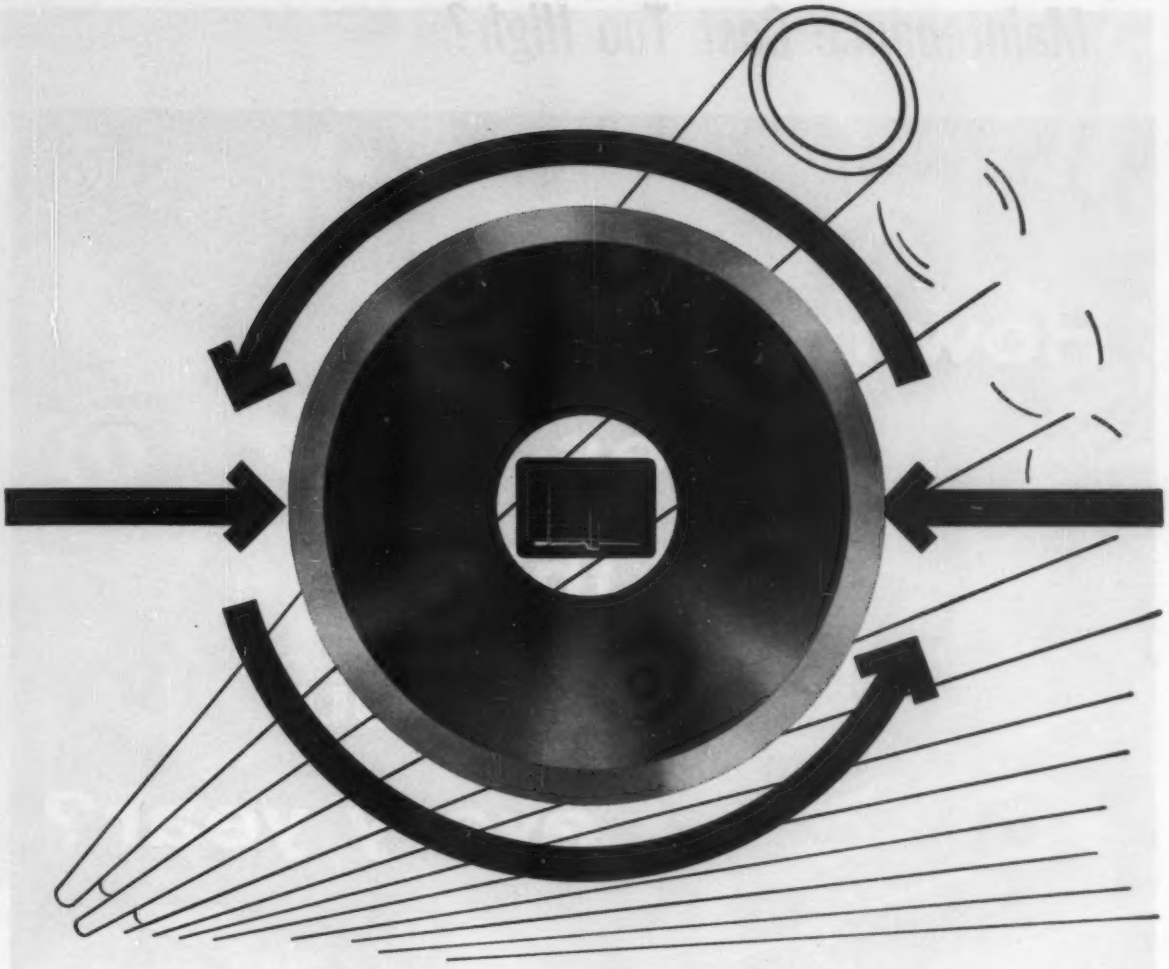
Information is provided on extending storage life of copper-contaminated gasoline stocks, heating oils and diesel fuel with metal deactivators of this series.

AMOCO 530 SERIES GASOLINE ANTIOXIDANTS

Each of the three major chemical types of gasoline antioxidants, for economical protection from gum formation, are included in the AMOCO 530 Series. Here are data on all of them.


PRODUCT BULLETIN
AMOCO CHEMICALS CORPORATION
AMOCO 193 Inhibitor
A Dialkyl
Zinc Dithiophosphate
PRODUCT BULLETIN
AMOCO CHEMICALS CORPORATION
AMOCO 200 Series
Detergent-Inhibitor
Additives
PRODUCT BULLETI
AMOCO CHEMICALS CORPORATION
AMOCO 600
Viscosity-Index Improv
A Linear Isobutylene Poly
PRODUCT BULL
AMOCO CHEMICALS CORPORATION
AMOCO 520 Se
Metal Deactiva
PRODUCT BULLETIN
AMOCO CHEMICALS CORPORATION
AMOCO 530 Series
Antioxidants
The most economical and effective protection from gum formation is available in the AMOCO 530 series antioxidants. The group consists of four products — AMOCO 531, 532, 533, 534 — and includes each of the major chemical types of gasoline antioxidants. From this AMOCO series, it is possible to select the proper treatment for each gasoline blend. Early addition to unstable streams saves antioxidant.
AMOCO 531 Antioxidant
N-Butyl-p-aminophenol in isopropanol
AMOCO 532 Antioxidant

AMOCO CHEMICALS CORPORATION
910 S. Michigan Avenue, Chicago 80, Illinois



B&W LECTROSONIC

A New Name for Carbon Steel Heat Exchanger Tubing

Dependability Proved by Five Years' Extensive Field Service

You get substantial savings with this sounder, more uniform tubing

B&W LECTROSONIC—a new name for heat exchanger tubing—is manufactured under the most exacting methods of quality control in the industry, to give you new standards of dimensional exactness and uniformity, ease of installation, and dependability—plus dollar-saving economy!

You can save on installation time. Every tube fits right and rolls in easily because it's uniform in size and tolerances. It bends easily *with the weld in any position.*

The weld is checked five ways—including 100% ultrasonic inspection—to give assurance of dependability.

This superior quality tubing was developed to meet the needs of the petrochemical industry for a dependable electric resistance welded carbon steel tube that is easily workable, strong, and less costly than seamless tubing formerly required.

B&W LECTROSONIC Tubing is available now either direct or through distributors.

Write today for B&W Bulletin TB-431 for full information—or call your nearest B&W District Sales Office. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

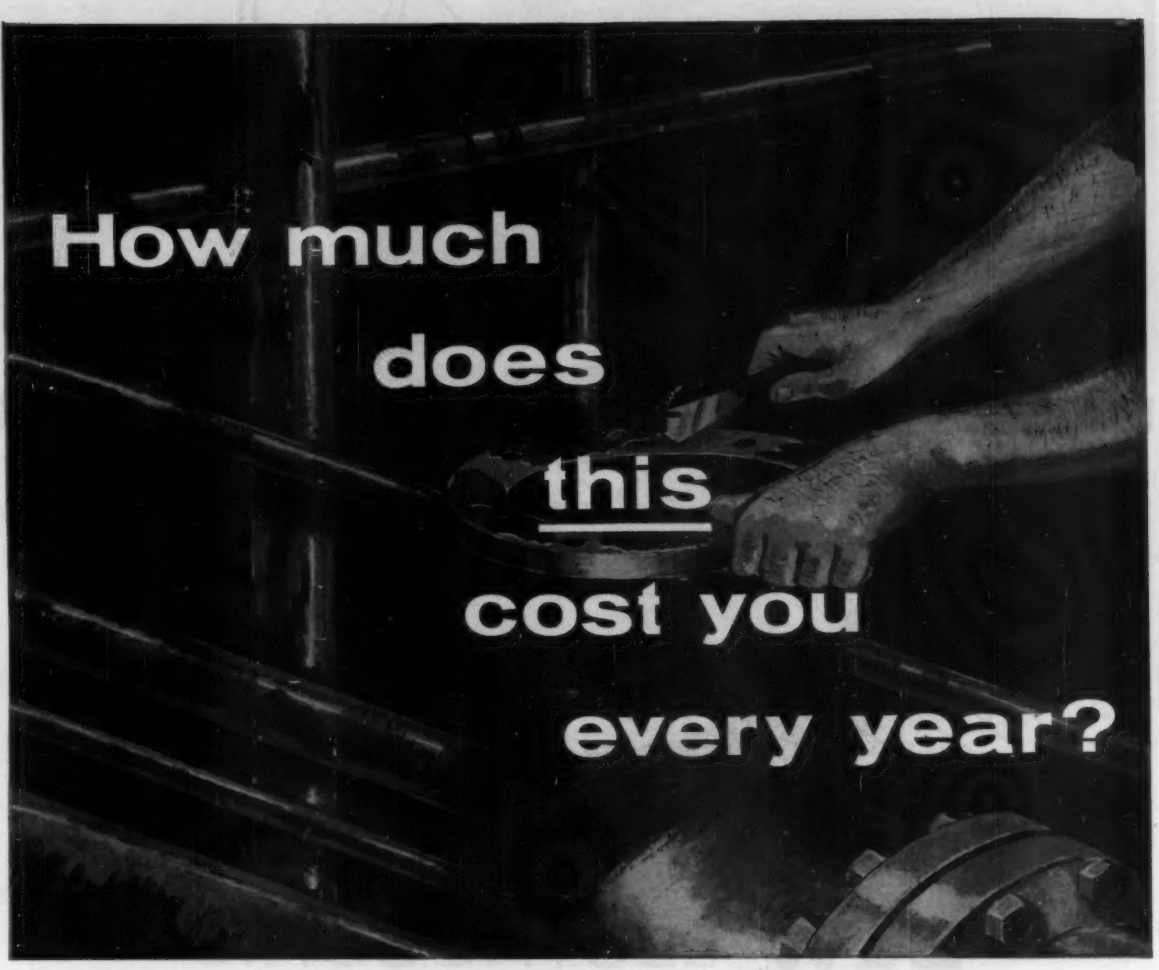
TUBULAR PRODUCTS DIVISION

TA-9033-WP4

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

For more data on advertised products, use Readers' Service Cards, last page.

Maintenance Cost Too High?



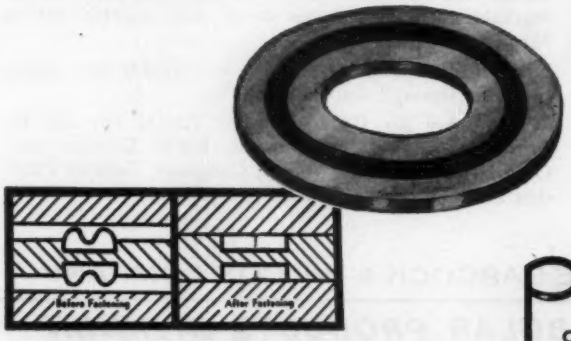
How much time, effort, and money is spent cleaning, resurfacing and/or replacing flanges to replace the seal!

Expensive? Yes!

Why not find out about Gask-O-Seals and save! Here are the facts: With Gask-O-Seal, flange faces require little or no cleaning or resurfacing of flanges when replacing the seal — *and Gask-O-Seals are re-usable.*

Gask-O-Seals save money and effort in many other ways, too. They are visually inspectable, do not need to be re-torqued, there is no material creep and they are non-directional, non-flexible, easy to install. They provide no-leakage sealing, *can not blow out,* and there is no wear due to pulse.

Now available to fit ASA standard flanges. Write for free catalog.



Note metal to metal contact.

Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

A DIVISION OF PARKER-HANNIFIN CORPORATION

MORE THAN MEETS THE EYE

Pastel and bright color combinations used in this Hudson designed and built plant are utilitarian and also pleasing to the eye.

But beyond the eye appeal is the built-in 30 years experience of Hudson in building gas processing plants in most gas producing regions of the free world.

Such experience combined with constant alertness for improvements results in trouble-free plants, built on time, with careful balance between capital cost and operating cost to assure maximum return on the investment.

The above pictured absorption plant processing 300 million cubic feet per day of gas at about 1000 pounds pressure is located on the Mermentau River in Cameron Parish near the Louisiana Gulf Coast, and was designed and built for the Superior Oil Company.

A refrigerated absorption process is used with provision for future further refrigeration down to minus 50°F to increase gas throughput and/or product recovery. The plant has operated uninterruptedly since initial test start-up in October 1958.

DESIGNERS AND CONSTRUCTORS OF PROCESS PLANTS FOR THE OIL, GAS, CHEMICAL, AND MINERAL INDUSTRIES

HUDSON

ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

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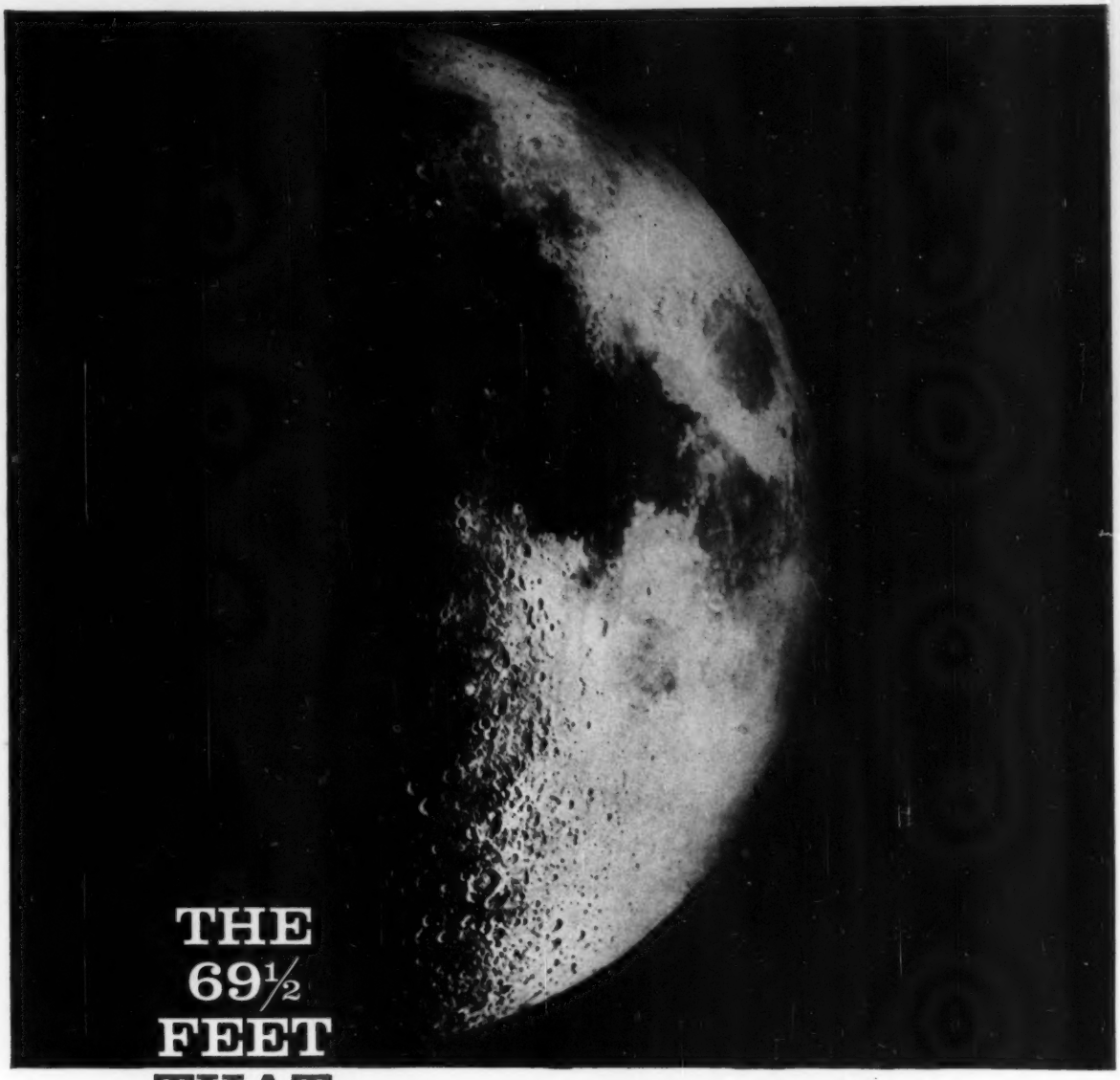


THE 69½ FEET THAT REACH THE MOON

Time: One hundred years ago—1859.

Place: Titusville, Pennsylvania.

Event: The first U. S. oil well "came in" at 69½ feet. And from it and its successors have come endless miracles of oil.

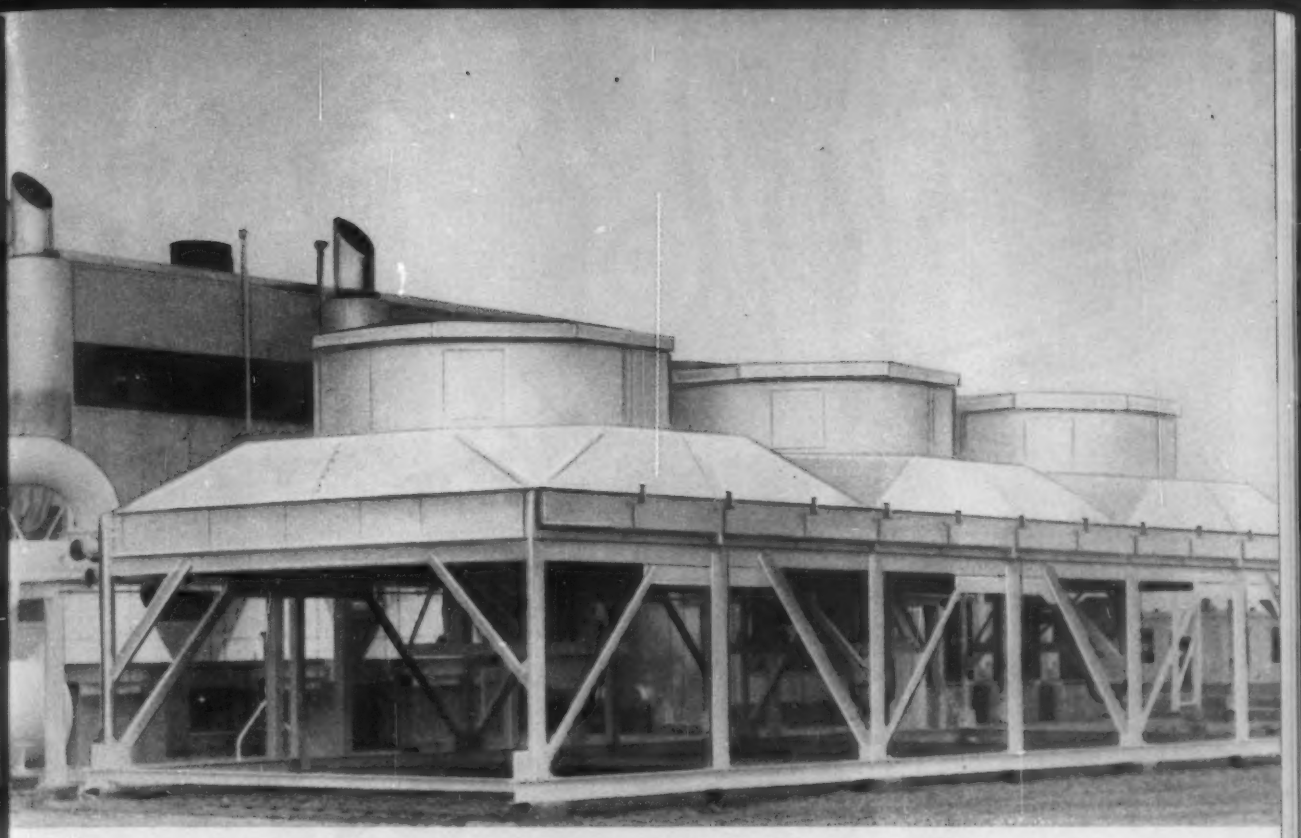
Today, petroleum gives us fuels that are capable of moving man from earth to the moon and beyond. Such explorations can bring new knowledge of incalculable value.

But no less certain than the conquest of space is that we will have ever better fuels and lubricants for travel on the ground, on the sea, and in the air—new and exciting products for the farm, industry and the home.

Today it is estimated that one quarter of all the money spent by U. S. industry on research is spent by the petroleum industry.

And as chemists study the endless ways to rearrange oil molecules to make useful products, we can see that the age of petroleum has only begun.

Standard Oil Company (New Jersey) Esso



Giant compressor and generator engines are cooled by 26 TRANE Fluid Coolers at 6 Trans-Canada stations. Both horizontal and vertical air discharge types are used.

Trans-Canada, longest gas pipeline in the world, chooses Trane Fluid Coolers to cool engine water!

The Trans-Canada Pipeline System—2,294 miles long—provides market outlets for reserves of Alberta natural gas, serves Western Canada, and the great industrial areas of Eastern Canada.

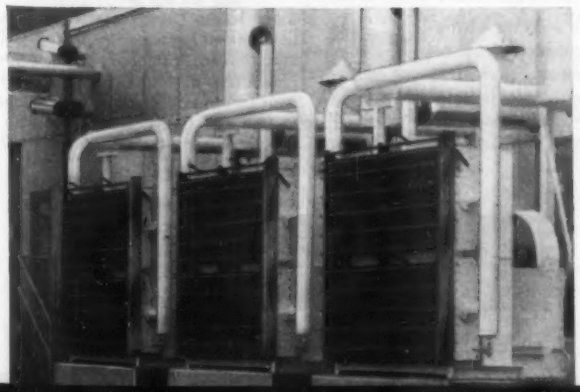
Because this pipeline passes through country where winter temperatures are very low, it was necessary to install engine jacket water cooling equipment that would function at 40 degrees below zero!

Trans-Canada chose TRANE Fluid Coolers for this important job. 26 TRANE units serve the initial six compressor stations. Air cooling was considered essential—and TRANE Fluid Coolers have shown that they can operate efficiently under all weather conditions.

More and more transmission companies are turning to TRANE for cooling equipment. Many have reported simplified maintenance, a minimum of adjustment problems. And engineers *know* that they can depend upon the accuracy and completeness of TRANE capacity ratings—tested in the industry's most complete laboratory, where as many as 90 different temperature readings are taken across the face of a heat transfer section!

When you have a fluid cooling problem, turn to TRANE! Just call your nearby TRANE Sales Office—or write TRANE, La Crosse, Wisconsin.

Small TRANE Horizontal Air Discharge Coolers cool the engines used to drive the 250-kilowatt generators (three per station) which supply electrical power on stations not served by a utility.

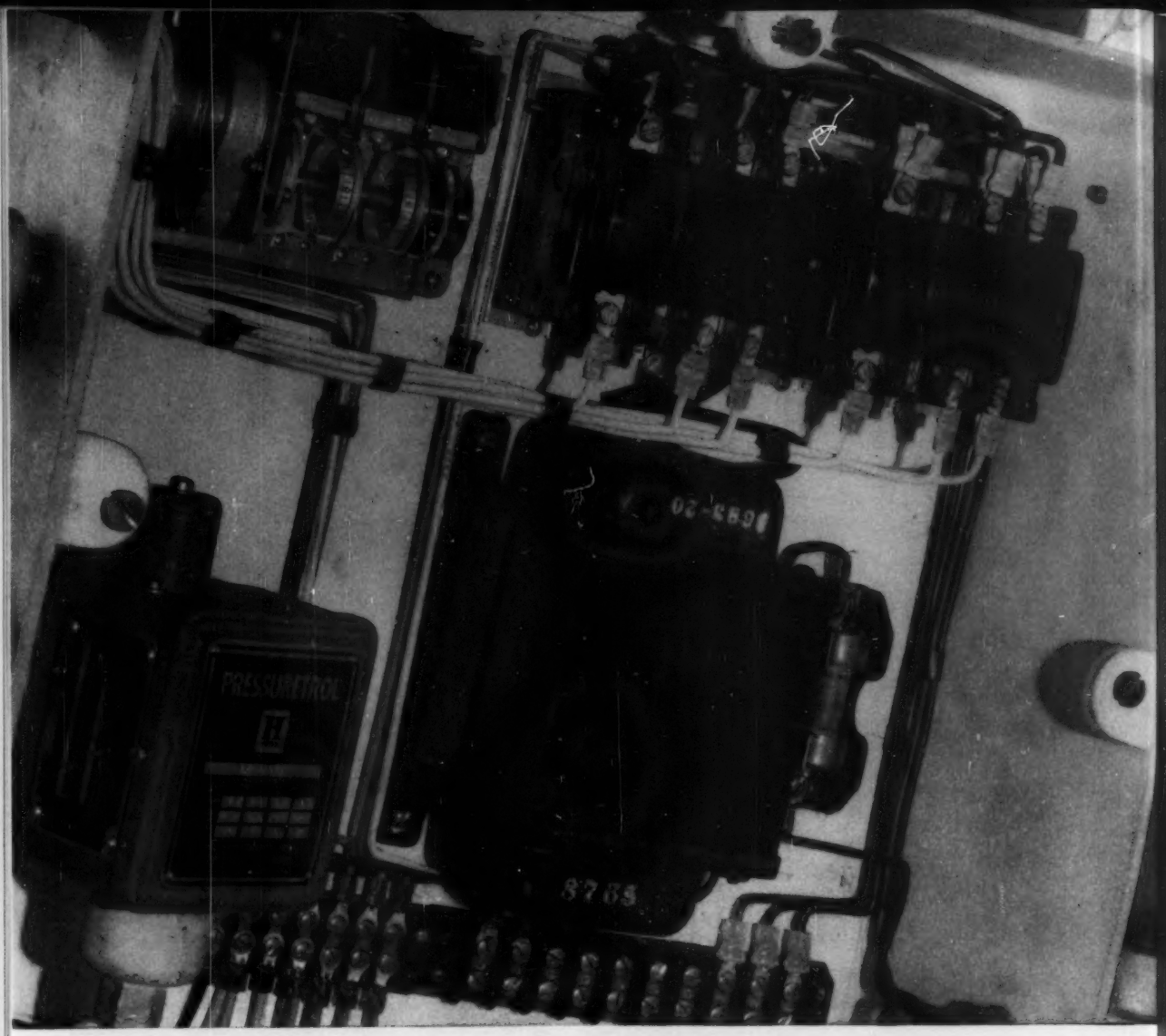


For any air condition, turn to

TRANE

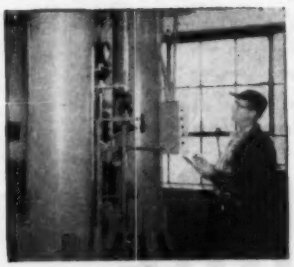
MANUFACTURING ENGINEERS OF AIR CONDITIONING, HEATING, VENTILATING AND HEAT TRANSFER EQUIPMENT

THE TRANE COMPANY, LA CROSSE, WIS. • SCRANTON MFG. DIV., SCRANTON, PA. • CLARKSVILLE MFG. DIV., CLARKSVILLE, TENN. • TRANE COMPANY OF CANADA, LIMITED, TORONTO • 100 U. S. AND 18 CANADIAN OFFICES



For "set it and forget it" gas drying—

Come to Kemp



Kemp Dryer protects instrument lines at −25° for Quaker State's Farmer's Valley, Pa. plant. Fully automatic operation saves time and manpower, yet provides dependable service on a 24 hour basis.

Here's the nerve center of every Kemp Fully Automatic Gas Drying Unit. Drying process gasses and inerts . . . air for pneumatic instruments and tools . . . liquids . . . for pressurizing anhydrous liquids . . . this panel controls the Kemp Dryer surely and safely. Once timed to meet your program, it provides efficient drying on a continuous basis, without worry or excessive maintenance.

Note the precision with which even the wiring is connected. It's typical of the thorough workmanship going into every component of the Kemp Dryer. Kemp Dryers are built with care; built to last and perform year after year with dependability resulting from a quarter century's experience.

Whether your operation calls for a completely automatic Kemp Dryer, a semi-automatic model, or a simple, manually operated unit, there's a model and capacity to meet your needs. Kemp Field Engineers will gladly study your problem and make complete recommendations, even down to the proper desiccant (we select from over 20) to do your job best.

Your Kemp Representative is listed in *Chemical Engineering Catalog*. Call him for full information when you plan a new installation or wish to update an old one. Or write for Bulletin D-102. THE C. M. KEMP MFG. CO., 405 E. Oliver St., Baltimore 2, Md.

Convection Dryers

Inert Gas Generators

KEMP OF BALTIMORE

Nitrogen Generators

Oriad Dryers

you'll have no "fogged-in" temperature readings with RMC thermometers

When you walk past an RMC thermometer you can *always* read the dial clearly —indoors or out, winter or summer. There will *never* be any *interior* fogging to obscure the dial.

That fact also assures you—if you are concerned with low temperature readings—that you don't have to worry about "bi-metal freeze-up"—a problem which can be considerably more serious than the obscured dial.

Both problems are caused by internal moisture which in one case condenses on the crystal, and in the other case freezes on the bi-metallic temperature re-acting element to "freeze" temperature readings at the lowest level.

RMC thermometers just don't have these problems because they are assembled and *hermetically sealed* under controlled, low humidity conditions. Each instrument is tested by immersing in water for fifteen minutes to be sure that no moisture will *ever* get in.

This is the kind of extra precaution our engineers like to take here because we are proud of the continued "in-service" accuracy of RMC thermometers.

We know that each one of our thermometers is accurate to within ½ to 1% of scale range when it leaves here—and we also know that it's going to stay that way regardless of the humidity conditions or temperature conditions to which it will be subjected.

Unvarying accuracy and dependability are the features of RMC instruments—and we've found, in our years of making thermometers, liquid level, and pressure gauges, that real accuracy is the result of unwavering attention to detail.

If you have any problem involving indicating instruments of this type, give us a phone call—or wire or write. If we don't carry such an instrument in stock, our engineers will be glad to work with you in the development of one to fit your exact needs.

Model 1740, shown here, is the new RMC 3"-dial straight form thermometer. As with all other models, the RMC **hermetic sealing process** makes absolutely certain that moisture can **never** effect its accuracy or readability.

Ralph Foster

RMC

ROCHESTER MANUFACTURING CO., INC.
38 ROCKWOOD STREET • ROCHESTER 10, N.Y.

LIQUID LEVEL, TEMPERATURE AND PRESSURE INSTRUMENTS

Representatives in all Principal Cities

For more data on advertised products, use Readers' Service Cards, last page.

750-HP turbo-gear unit with double ended low-speed gear shaft—for installation in center of paper machine line shaft.

LOW-SPEED TURBINE DRIVES

tailored to meet your requirements

For more than half a century, Terry has been one of the principal suppliers of turbo-gear units for driving slow-speed fans, generators, paper machines, large pumps and the like. Each unit is designed to meet the job requirements. The paper-machine drive illustrated is a good example of this *individualized engineering.*

In service at a large southeastern paper mill, the unit delivers 750 HP at 3350/500 RPM, with steam conditions of 450 lbs., 660°F and 50 lbs. back pressure. Equipped with a variable-speed governor, operated by remote control, the speed of the unit may be varied through a 10:1 range. Other features include forced-feed lubrication to turbine and gear bearings, and automatic shutdown and alarm in case of low oil pressure.

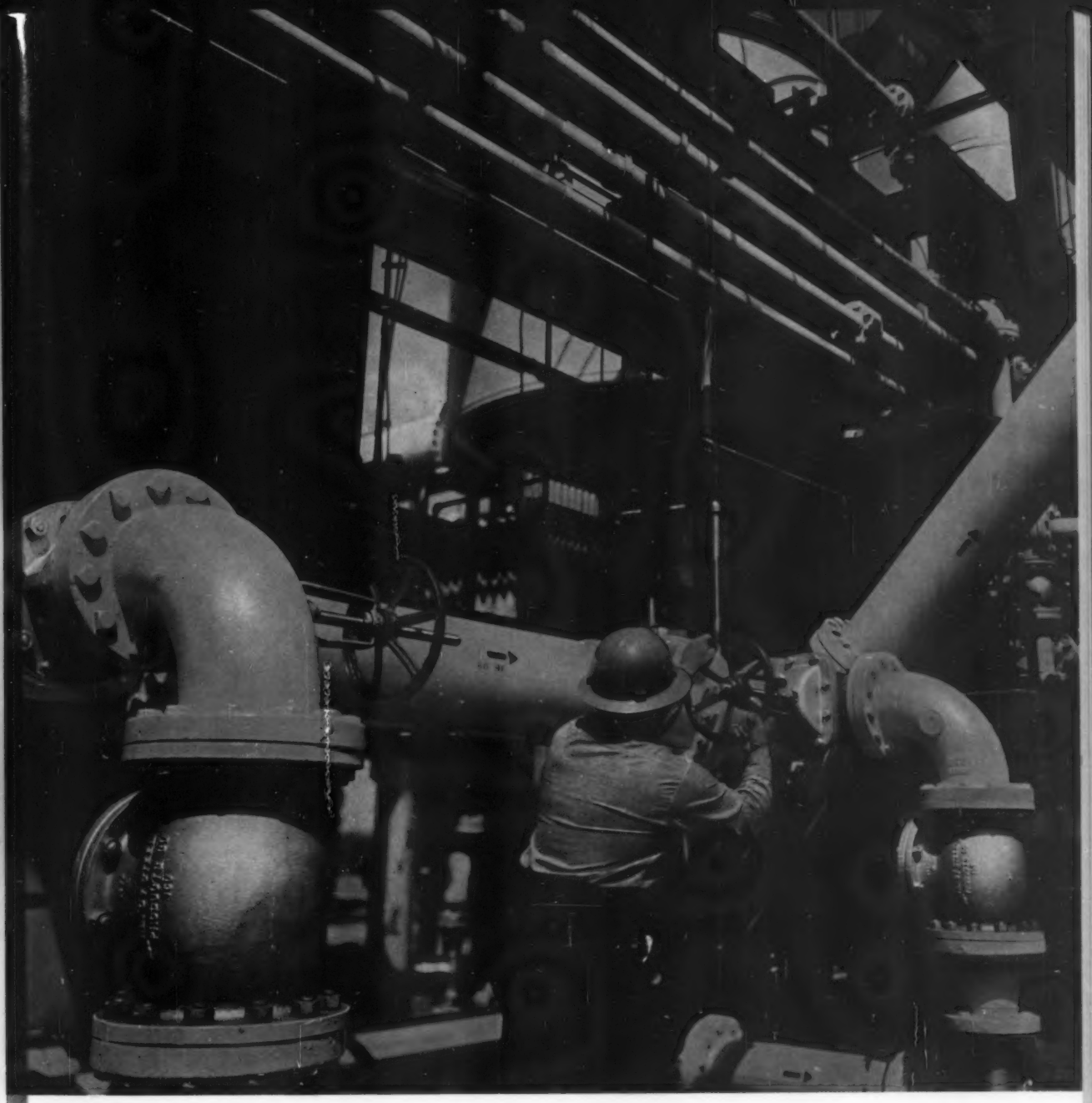
Whatever *your* requirements for low-speed turbine drives, a Terry engineer will be pleased to discuss them with you. Bulletin S-140 covers the full line of Terry turbines; Terry gears are described in bulletin S-130.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

11-1212

For more data on advertised products, use Readers' Service Cards, last page.



Aloyco Valves in General Chemical's new "dream" plant

The Aloyco Valves you see here are controlling the flow of 98% acid in the new sulfuric acid plant of General Chemical Division, Allied Chemical Corporation, at Elizabeth, New Jersey.

The plant utilizes most modern processing techniques. All equipment was chosen for its special ability to contribute to operating efficiency and long life.

For example, valves made in Aloyco 20, an alloy exceptionally resistant to corrosion from sulfuric acid, were specified for handling spent and sludge acids, as well as finished strong acid and oleum.

When you are selecting valves for corrosive service, remember only Alloy Steel Products Co. specializes in Stainless Steel Valves exclusively. Call our local representative or write us at 1301 West Elizabeth Avenue, Linden, N. J. 9.2

ALLOY STEEL PRODUCTS COMPANY

Boston · New York · Wilmington · Atlanta · Buffalo · Pittsburgh · Chicago · St. Louis · San Francisco · Los Angeles

After 5,000 years of mud... superhighways of petroleum

▲ **YESTERDAY.** Muddy roads clutched at the world's wheels, slowing transportation to a worm's pace. Then at last, man found he could make smooth, hard-surfaced roads from asphalt — a non-volatile form of petroleum. In the early promotion of asphalt road-building, Texaco took a prominent part.

◀ **TODAY.** Texaco is one of the world's largest manufacturers of asphalt products. These products make possible great ribbons of smooth superhighways, as well as airport landing strips. They are used for roofing, battery boxes and many other useful items. Texaco's leadership and growth in this field result from its policy of constantly planning for the future. THE TEXAS COMPANY

TEXACO
... CONSTANT PROGRESS IN OIL'S FIRST CENTURY

CHIKSAN HELPS UNION OIL CUT OUT THE COKE

Swiveling Chiksan Decoking Arms combine flexibility and stamina to handle 1700 psi hydraulic water force used to remove petroleum coke from coke drums

During refining of crude stock at Union Oil's Oleum refinery, petroleum coke is produced as a valuable by-product. When coke drums become full, they are "decoked" with a high pressure water jet which first drills out a pilot hole, then cuts the coke loose, moving it out of the tower in slurry form. Safety dictates all metal flexible lines. The solution—Chiksan Swivel-Jointed All Steel Decoking Arms. These rugged units provide free turning rotation with all movement carried out in a predetermined arc. Service life of the Chiksan Decoking Arms is measured in years and maintenance involves an occasional packing replacement. If your equipment or plant lines require flexibility, let Chiksan swivel joints provide the answer with less maintenance, limited replacements, and the safety that only steel can provide. Write today for literature and price lists.

LOOK INSIDE A SWIVEL JOINT. Detailed attention to detail. Precision machining and specific packing seals for specific services. These are the quality-plus features built into every Chiksan Swivel Joint.

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

fmc CHIKSAN

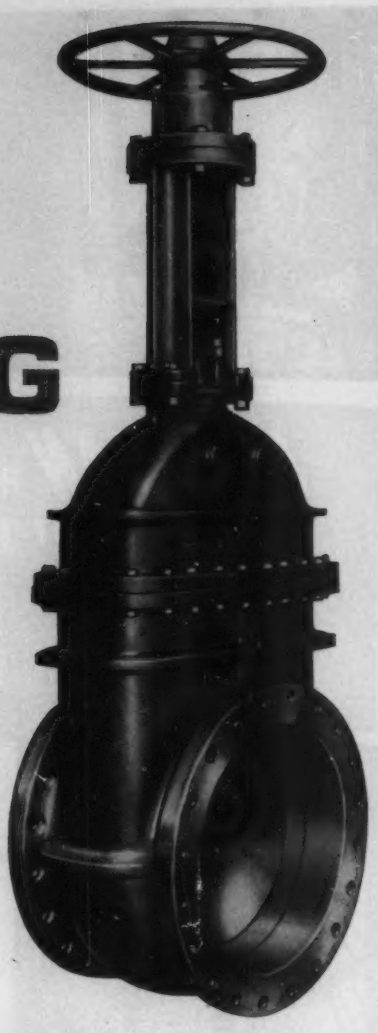
Please Address Dept. 62

CHIKSAN COMPANY—BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

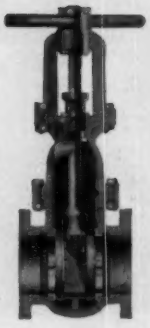
Well Equipment Mfg Corp (Division), Houston 1, Texas • Subsidiaries Chiksan Export Company • Chiksan of Canada Ltd.

#57-29

HANDLING "PROBLEM" FLUIDS OR GASES?



Specify ALUMINUM GATE VALVES by Darling



Aluminum flanged end gate valve. Also available with other types of ends. Can be furnished with inside screw stationary stem.

Where you're handling highly corrosive materials... or where valve weight is a factor... Darling Aluminum Gate Valves make sound economic sense.

High-corrosion-resistant aluminum alloys... carefully selected and thoroughly tested by Darling metallurgical engineers... are used for structural and pressure-containing parts. They've been *proved-in-use* as the most generally corrosive-resistant aluminum alloys in use today.

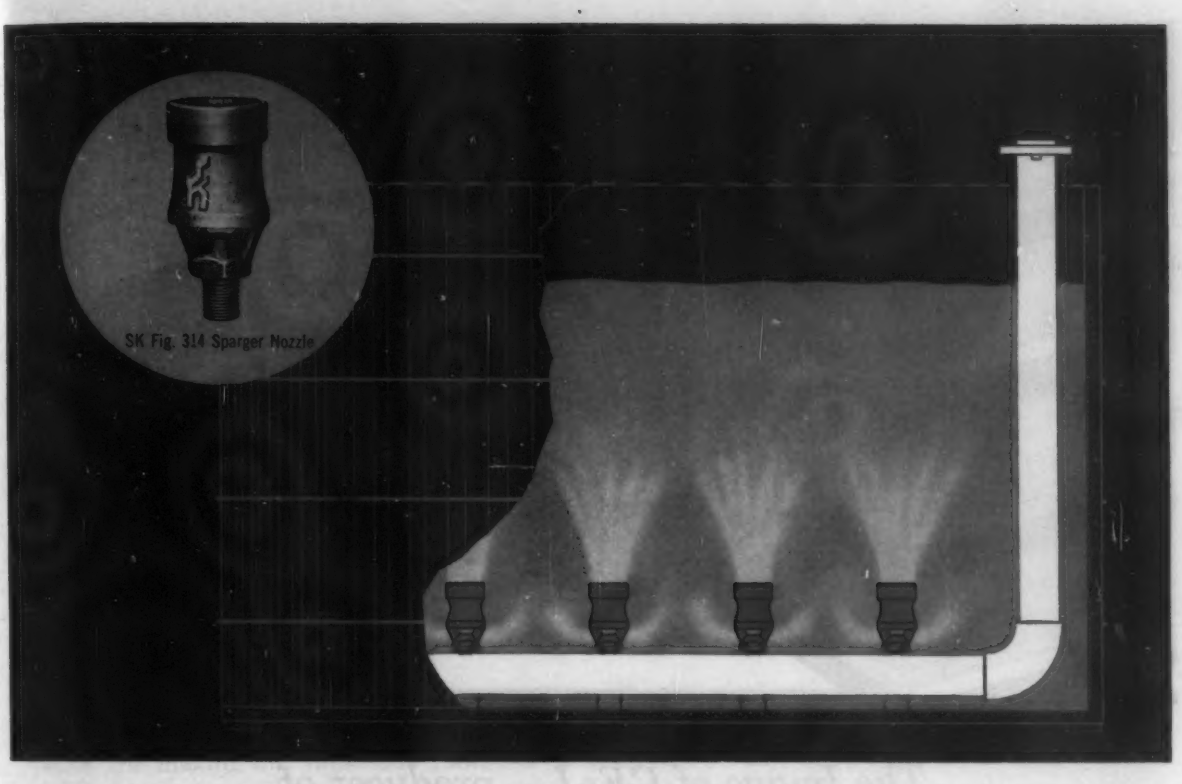
Double disc parallel seat principle assures maximum life under the most exacting service conditions. "No pocket" discs and wedges prevent accumulation of line scale or sludge. Wedge design reduces friction to a minimum, assures positive sealing and ease of operation.

DARLING VALVE & MANUFACTURING CO.

Williamsport 31, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

For more data on advertised products, use Readers' Service Cards, last page.



HOW TO HEAT AND AGITATE LIQUIDS IN TANKS

efficiently, economically, and with less noise

SK Fig. 301 Noiseless Heater for Tank Heating

SK Fig. 315 Circulating Heater for Tank Heating

SK Fig. 320 Continuous Heater for Pipe-Line Heating

SK Fig. 327 Slurry Heater for Pipe-Line Heating

Do it with plant steam and SK Steam Jet Heaters.

These Heaters utilize the jet principle to mix steam with a cold liquid, uniformly and without the noise and vibration usually associated with such operations. Since all of the heat in the steam is absorbed by the tank liquid being heated, operation is efficient. Because the jet action of the Heaters produces agitation and circulation, you need no additional equipment to perform these functions. Furthermore, since Steam Jet Heaters have no moving parts (except an adjusting spindle on some pipe-line types), you get long, trouble-free service without costly supervision and maintenance.

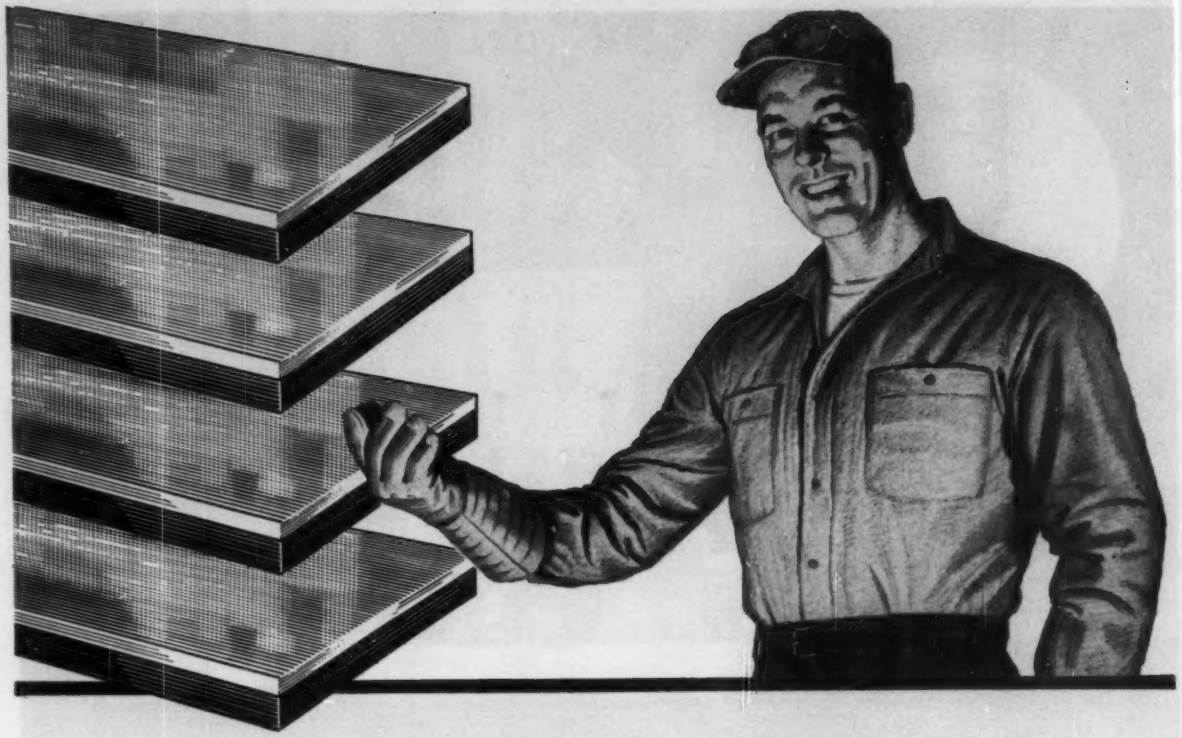
The illustration above shows tank heating being accomplished using SK Sparger Nozzles—one of the several types of Heaters offered by SK. Units of this type are ideal for use where uniform agitation is required over a large shallow tank area. In operation, a jet of steam issuing through the nozzle entrains tank liquid through the suction opening. Condensation takes place immediately upon mixing of liquid and steam and the stream of heated liquid is discharged at considerable velocity providing constant agitation.

Several other types of SK Steam Jet Heaters—for both tank and pipe-line heating—are shown at left. Complete details on all types are contained in Bulletin 3A which is available on request.

JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin M-1.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin G-1.

Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS SINCE 1876
2217 State Road, Cornwells Heights, Bucks County, Pa.

For more data on advertised products, use Readers' Service Cards, last page.



The Image of CF&I... producer of

CLAYMONT
STAINLESS-CLAD PLATE

This giant steelman symbolizes CF&I ... one of America's top-ranking primary producers of quality steel products. He reflects CF&I's pledge..."not merely to *sell* but to *serve*"... by supplying ever-improved products for industry's new and more demanding requirements. Products like CF&I-Claymont Stainless-Clad Steel Plate.

Claymont Stainless-Clad Plate...

- provides the same *protection*—against corrosion, abrasion or product contamination—as solid stainless steel, on applications where only one side of the plate is exposed to such wear factors.
- provides the *economy* of a carbon or alloy steel backing plate.
- is supplied in AISI stainless specifications 304, 304L, 316, 316L, 316Cb, 321, 347, 405, 410, 430 and ASTM specifications A-263 and A-264, plus others to meet special requirements.

The stainless cladding... from 5% to 50% of total plate thickness... is inseparably bonded to the backing plate.

Get full details from the CF&I sales office nearest you.

CF&I-CLAYMONT PRODUCTS: Carbon Steel Plates · Alloy Steel Plates · CF&I Lectro-Clad Nickel Plated Steel Plates · Clay-Loy High Strength Low Alloy Steel Plates · Flanged and Dished Heads · Manhole Fittings and Covers · Fabricated Steel Plate Products Large Diameter API Pipe

Claymont Steel Products

THE COLORADO FUEL AND IRON CORPORATION

CF&I STEEL

In the West: **THE COLORADO FUEL AND IRON CORPORATION**—Albuquerque · Amarillo · Billings · Boise · Butte · Denver · El Paso · Farmington (N. M.) · Ft. Worth Houston · Kansas City · Lincoln · Los Angeles · Oakland · Odessa · Oklahoma City · Phoenix · Portland (Ore.) · Pueblo · Salt Lake City · San Francisco · San Leandro Seattle · Spokane · Tulsa · Wichita

In the East: **WICKWIRE SPENCER STEEL DIVISION**—Atlanta · Boston · Buffalo · Chicago · Detroit · New Orleans · New York · Philadelphia

CF&I OFFICE IN CANADA: Montreal · **CANADIAN REPRESENTATIVES AT:** Calgary · Edmonton · Vancouver · Winnipeg

6921

use **MUELLER**® *drilling machines*

TO TAP LINES

TIE-IN LINES

RECONDITION VALVE SEATS

STOP-OFF LINES

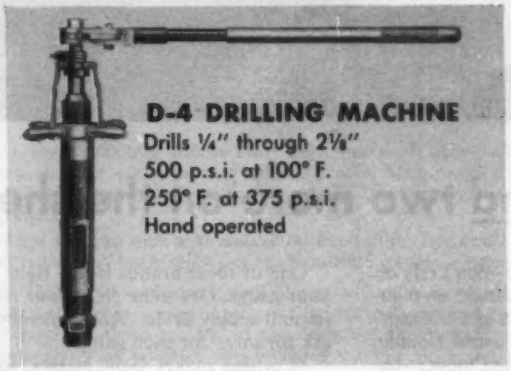
. . . SAFELY under pressure

Mueller Small Drilling Machines are widely used for making hot taps. But these machines have many other important applications and uses that do not always involve drilling. They are the basic machines used to perform the many different No-Blo operations.

These No-Blo operations, which were developed by the Mueller Co., permit hot taps, tie-ins, transfer of service from one line to another, repairs, replacements and a host of other tasks to be done in a completely controlled manner. All work is done safely and simply under pressure without escape or loss of fluid.

Ask your Mueller Representative or write direct for full information on Mueller's complete line of No-Blo Drilling Machines and Fittings—and what they can do to solve your piping problems.

Available for use with lines up to 12" at pressures to 1200 p.s.i. Suitable for air, water, gas, crude or refined oils, steam or chemical piping of any kind.



D-4 DRILLING MACHINE
Drills ¼" through 2⅛"
500 p.s.i. at 100° F.
250° F. at 375 p.s.i.
Hand operated

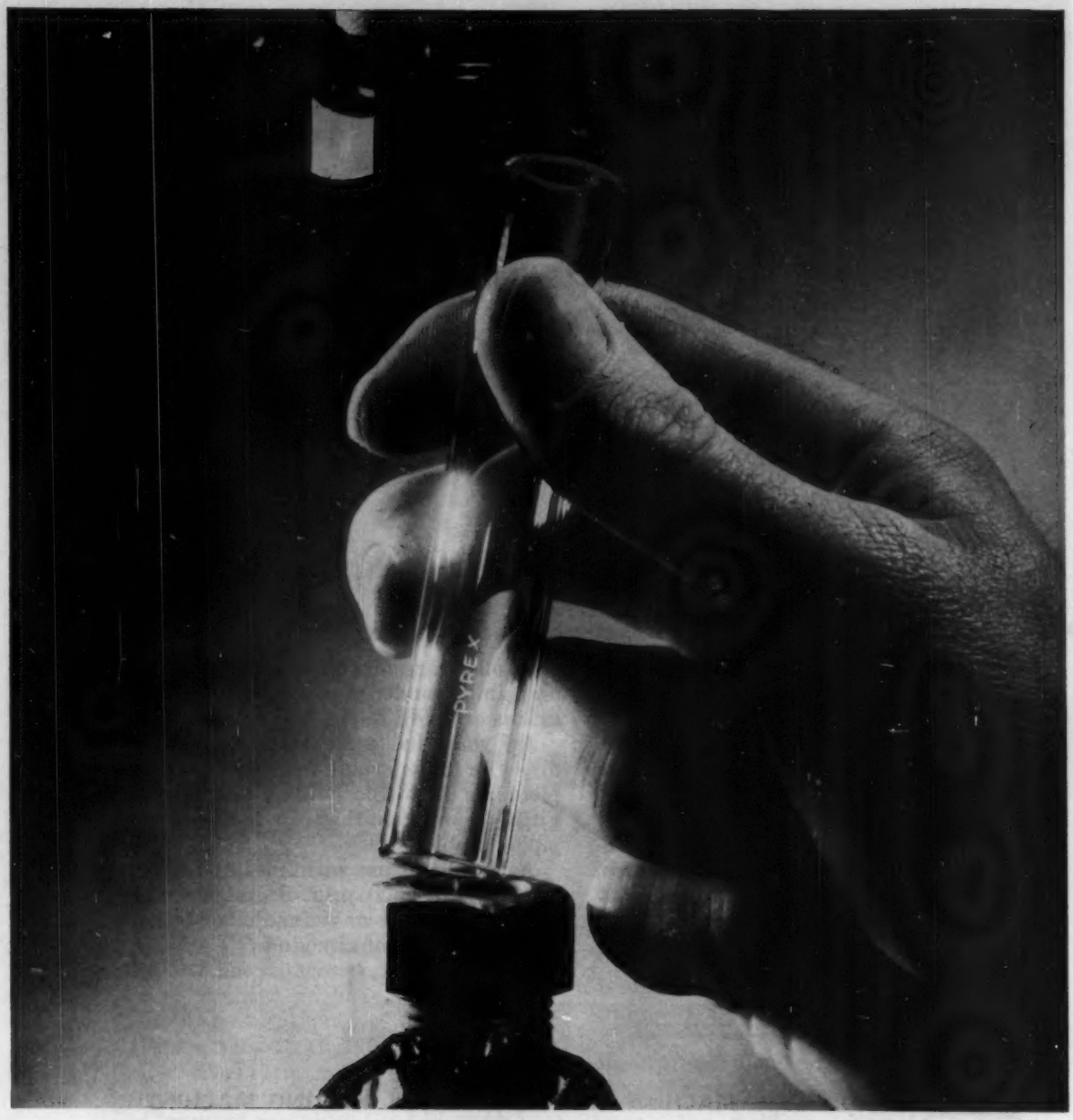
E-4 DRILLING MACHINE
Drills ¼" through 1"
500 p.s.i. at 100° F.
250° F. at 375 p.s.i.
Hand operated

Other drilling machines available for pressures to 1200 p.s.i. and temperatures to 500° F. and for drilling from ⅛" through 12".

NO-BLO®

MUELLER CO.
DECATUR, ILL.
Factories at: Decatur, Chattanooga, Los Angeles; In Canada: Mueller, Limited, Sarnia, Ontario

For more data on advertised products, use Readers' Service Cards, last page.



A gauge glass installed...and two more on the shelf

Make short work of gauge glass replacement—when the replacement is as near as your stockroom shelves. You'll cut down time.

Take *three* gauge glasses the next time you order from your distributor. That gives you *one* for the gauge right away, a *second* for regular replacement, a *third* to cover special emergencies.

And here's another tip—don't rely on any old type gauge glass. Insist on regular replacement with PYREX®, CORNING®, or MACBETH® to avoid trouble.

These gauge glasses last longer—because they're harder to break! They stand up better to just about every clouding hazard. They easily resist high temperatures and high pressures.

One of these brands is just right for your gauge. Get some from your regular mill supply dealer. And remember—ask for *three* for each gauge!

(Corning makes sight glasses, too—from tough PYREX brand glass. Use them whenever you must see what's going on inside your processing equipment. Your distributor has them.)

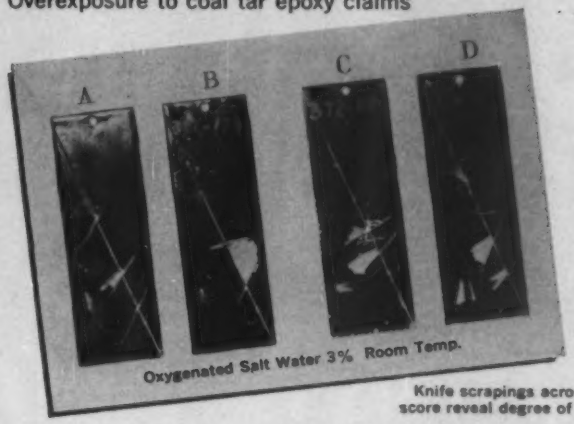
Corning means research in Glass

CORNING GLASS WORKS, Corning, N. Y.

For more data on advertised products, use Readers' Service Cards, last page.

SUFFERING FROM COALTAREPOXICATION?*

*Overexposure to coal tar epoxy claims



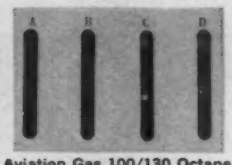
Knife scrapings across diagonal score reveal degree of undercutting.

Caustic Soda 5% Room Temp.

Sulfuric Acid 10% Room Temp.

Sulfuric Acid 30% Room Temp.

Sodium Hypochlorite 5% Room Temp.


Aviation Gas 100/130 Octane Room Temp.

Salt Spray (scored panels) Room Temp.

Distilled Water 140°F

Distilled Water Boiling

Sodium Chloride 20% Boiling

Sour Crude 120°F

JP-4 Jet Fuel 120°F

Aromatic petroleum hydrocarbon solvent—120°F

Try these tests to end the confusion

116

So many conflicting claims have been made about virtually every coal tar epoxy coating on the market that prospective users are finding it difficult to fish out the facts from a sea of superlatives.

Perhaps you can find *your* answer by duplicating any or all of these laboratory tests comparing the four leading coal tar epoxies.

THE TESTS: The rods and panels illustrated here were carefully coated to the four manufacturers' specifications and then subjected for three months to the corrosive agents indicated above. The wide range of tests included varying concentrations of chemicals, ambient and elevated temperatures, weathering and all usual types of exposure.

THE RESULTS: Some results were predictable, such as the failure of all four coatings to withstand aromatic petroleum hydrocarbon solvent. But striking differences occurred in such tests as oxygenated salt water, when only Coating A (Amercoat No. 78) resisted undercutting. Products B, C and D were all blistered and undercut to varying degrees. In none of the remaining tests was Amercoat No. 78 excelled, and in most cases it showed marked superiority.

CONFIRMATION: The properties attributed to No. 78 in these tests have been substantiated repeatedly in actual field use. Applicators like it because it (1) gives dependable, all-around protection, (2) sprays more easily than competitive products, (3) builds thick films without difficulty because of its higher solids content, and (4) dries thoroughly but at a moderate rate, avoiding the extremes of prolonged tackiness and fast-dried brittleness.

Because of the unusual importance of these tests to prospective users of coal tar epoxy coatings, we have prepared illustrated copies of the complete report. Write for yours today!

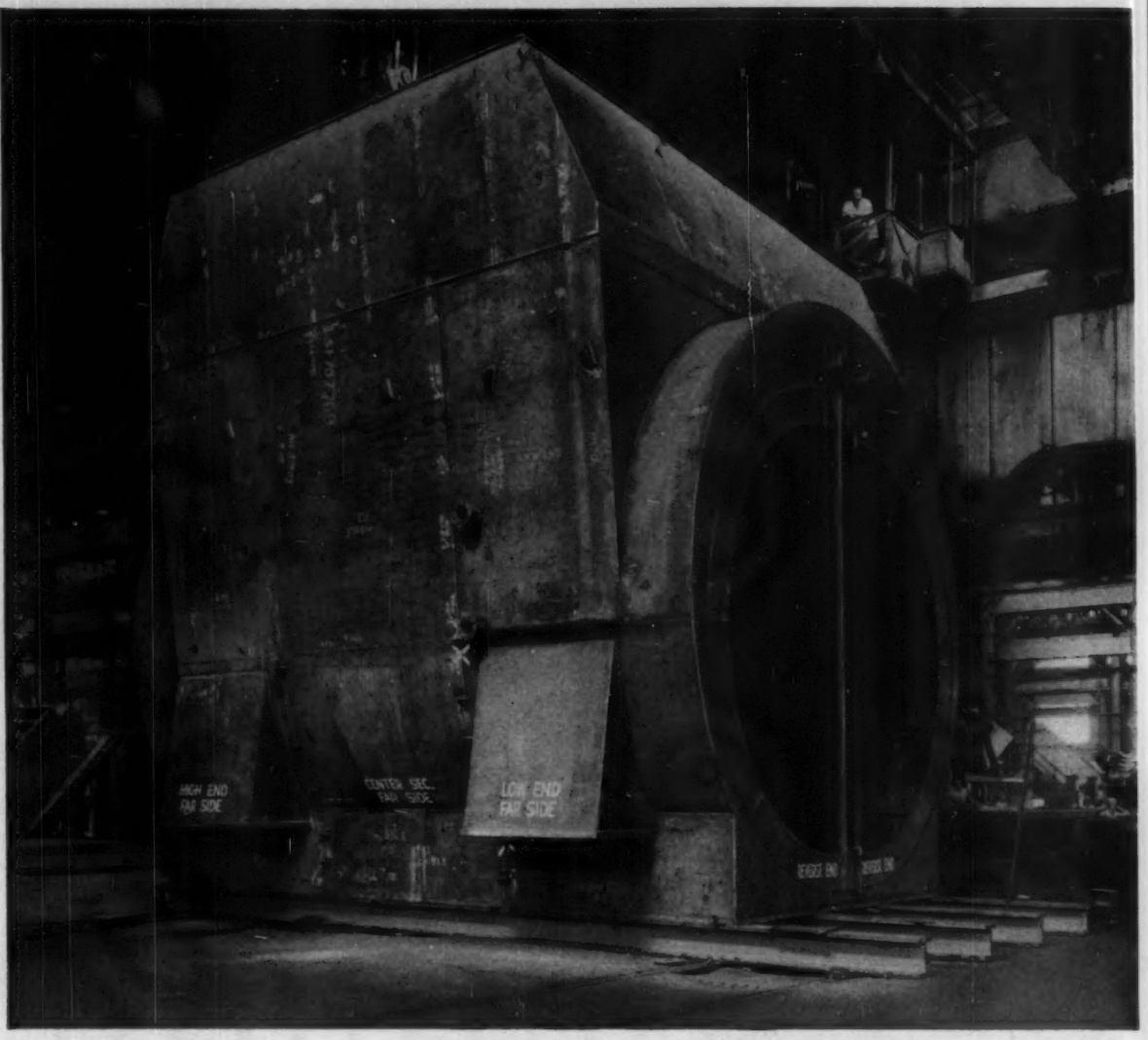
(Amercoat No. 78 was formerly designated No. 1686)

Amercoat® CORPORATION

Dept. VH
4809 Firestone Boulevard
South Gate, California

921 Pitner Ave. Evanston, Ill. | 360 Carnegie Ave. Kenilworth, N.J | 2404 Dennis St. Jacksonville, Fla. | 6530 Supply Row Houston, Texas

For more data on advertised products, use Readers' Service Cards, last page.



Operator of overhead crane (top, right) and workmen on shop floor are dwarfed by the enormousness of this surface condenser casing fabricated by B-L-H's Eddystone Division.

No welding job too big for vast B-L-H facilities

No welding job—not even the biggest pressure vessels—is too large for the facilities of Baldwin-Lima-Hamilton's Eddystone Division. The fabricating shop covers 15 acres and is divided into 13 bays, each 80 ft. wide and 600 ft. long.

Sheer size does not, of course, even begin to tell the whole story. From automatic tracer flame cutters to individual hand welders, we have a tool for every conceivable operation. And there is no reason for you to spend money transporting formed parts to Eddystone for welding—or completed weldments to some other shop for machining. We can handle every phase of the job—from design right through to delivery. No wonder so many companies bring the big ones to B-L-H.

Our illustrated Weldment Bulletin 7001 will give you an excellent idea of our vast facilities. You should have it in your files. For a copy, write to B-L-H Corporation, Philadelphia 42, Pa.

BALDWIN · LIMA · HAMILTON

Eddystone Division

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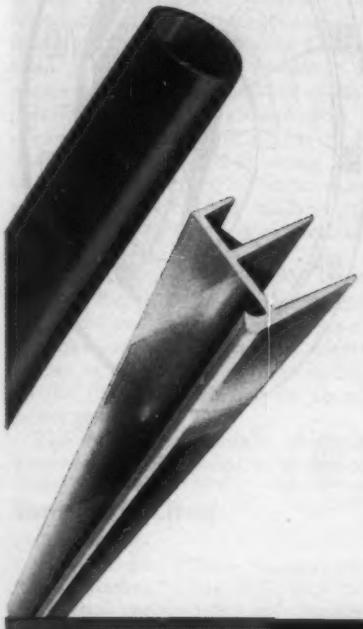

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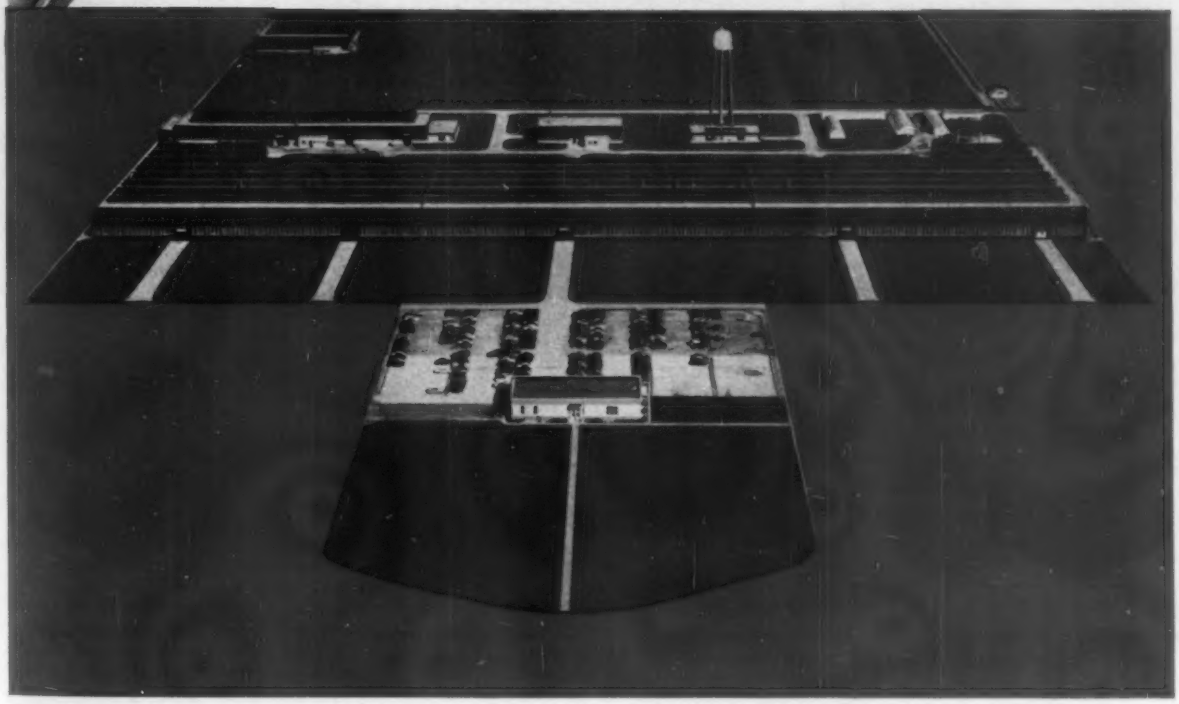
***The Other One? Wolverine's newly-modernized Detroit plant.**



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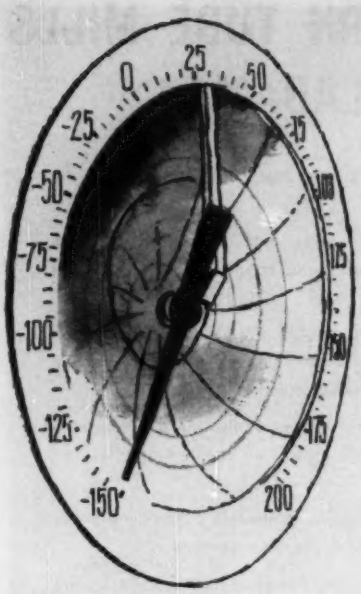
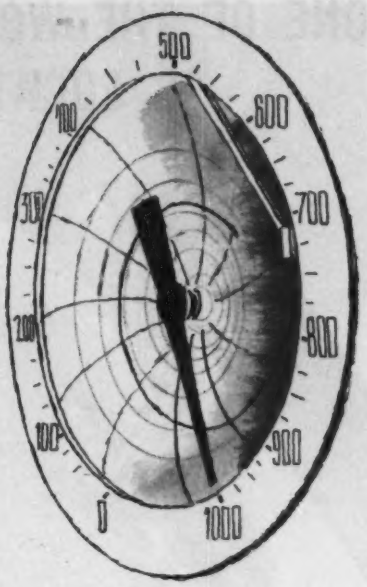


Whatever the temperature



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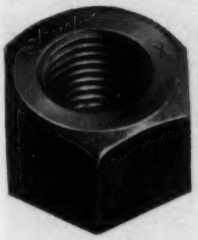

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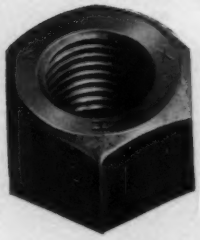

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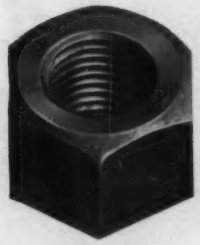

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low temperatures

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The Mail Box...

Editor's Note: *Below is an answer to a letter from* PETROLEUM REFINER *to Leroy E. Burney, surgeon general of the United States, protesting his recent derogatory statements about the refining industry. Dr. Burney had testified before a House committee regarding increased cooperation of other industries seeking less air pollution. "I cannot say the same thing for oil refiners," he was quoted as saying. PR's letter cited the research instituted and money expended ($66 million since 1956) by oil refiners on air pollution control. The reply:*

Your letter of May 18, 1959, to the Surgeon General, concerning his testimony before the House Appropriations Subcommittee, has been referred to me, as this office has responsibility for the Public Health Service air pollution program.

The Surgeon General's comments were not part of a prepared statement, but were made in response to the chairman's questions concerning the control of automotive exhaust in community air pollution. His statement did not relate to the much larger research and control effort by the petroleum industry in air pollution problems arising from its production, processing and distributing functions.

In order to fully clarify the matter, the Surgeon General has had a statement inserted into the record of the Senate Appropriations Subcommittee. This statement, which will appear in the published report of the Senate Subcommittee, includes an up-to-date highlight summary of auto exhaust research activities of the petroleum industry.

Your reference to the activity of the petroleum industry in studying and controlling refinery wastes is reassuring because the specific problem of auto exhaust air pollution is extremely complex and is one that will require a substantial research effort—both by industry and by government. The petroleum industry, with its demonstrated research capacity, is in a key position to make significant contributions in this area of need.

Wesley E. Gilbertson, Chief
Division of Engineering Services
Washington, D. C.

Summary Cited

To The Editor:

In our article, "These Factors Affect Rate of Return," (July 1959, page 117) you deleted our summary and conclusion section. In this section we made two points, 1) our feeling on the importance of interest rate of return and, 2) a possible standard to use. The following is excerpted from the deleted section of our article and contains these two points.

"We have shown the various factors that are not included in a return. One may get the impression that we do not believe that a rate of return has a useful place in an investment decision. This is not so! The rate of return reduces the costs and income numbers into a single comparative number and as such fulfills an important objective. We would like to see the factors encompassed by a rate of return expanded; i.e. use a statistical approach to incorporate market prediction and process design confidence levels into a rate of return. The point we are making is that a rate of return, **alone**, should not be used to make an investment decision.

"If all the other factors have been evaluated, and a decision rests on the magnitude of the rate of return, then a useful standard would be the cost of equity capital. This cost indicates the rate of earnings of a company's average existing investment. Thus, a new project should have a rate of return equal to or greater than this figure or else if a majority of the projects are below, this rate will eventually shrink. A company should also compare the average return with the average for the industry. If they find the return lower than the industry's, the new project should be higher than the industry's rate of return."

BONNER & MOORE
ENGINEERING ASSOCIATES
Houston — Louis P. Karvelas

Collateral Reading

To The Editor:

I have read with interest two excellent articles in your May 1958 issue, "Human Relations Can Be Dangerous" and "What It Takes To Bargain With Labor."

I would like to use these articles as collateral reading in my Industrial Relations course and if they are available I would appreciate several copies of each.

W. Roy Buckwalter, Professor of Management
Temple University
Philadelphia

Spots Oversight

To The Editor:

After presentation of the paper, "The Giammarco-Vetrocoke Processes for Acid Gas Removal," and its subsequent publication in PETROLEUM REFINER (May, 1959) we discovered an error which we hope to correct, with your assistance.

The mistake appeared in Table 2, page 165. The value given for "H_2S Out, Grain/100 Standard cu. ft." under "Manchester" should be < 0.1 Gr./100 Std. cu. ft., instead of 0.25 Gr./100 Std. cu. ft. This means a great deal to the owners of this process, who brought the unfortunate oversight to our attention.

Actually the Manchester Process is capable of producing gas of considerably higher purity than indicated in our paper.

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After the process and engineering design is complete, the specification writer can save his company real money on equipment by following these steps:

- **Write complete specifications.**
- **Avoid non-essential details and ambiguous statements.**
- **Be realistic in the design conditions you specify.**
- **Balance practicability, cost and performance.**
- **Permit manufacturers to quote on standard equipment if possible.**
- **Use a standard specification form and vendor's data sheet. They eliminate errors, help in bid evaluation and cut specification time.**
- **Use code materials where possible.**
- **Give enough detail to describe the mechanical characteristics desired.**
- **Allow enough time for the vendors to quote.**
- **Provide time for a thorough bid evaluation.**
- **Complete all the blanks on your data sheet.**
- **Allow the supplier to make alternate offers for consideration, but point out unacceptable features for a particular application.**
- **Check and double check the operating conditions.**
- **Give the vendor enough process data so that he doesn't have to guess.**
- **Don't go overboard in specifying small details.**
- **Ask for enough vendor literature to fully analyze the bid.**
- **Let the vendor use his standards or suggest improvements in your design.**
- **Make a last check—did you tell the vendor what you want?**

Frank L. Evans
MAINTENANCE AND DESIGN EDITOR

How to

Use this guide to help you raise questions to the heater designer and assure yourself that all the essential elements have been considered

Frank L. Maker
Institute Francais de Petrole
Sein-et-Oise, France

DESIGNING a fired heater is a job for a specialist. To design a heater requires a wide range of knowledge and experience, involving problems of heat transfer, combustion, and fluid flow, as well as structural problems. There are also tricky problems of arrangement of the various elements.

This guide will not qualify you as an expert heater designer, but you will be able to raise questions to the designer and assure yourself that all the essential elements have been considered.

The basic requirements for the heater are developed when the process heat and material balance is made.

HEAT AND MATERIAL BALANCE

The operating company's Process Design Section will have made heat and material balances for the plant in which the heater is required. There may even be several of these to cover different possible operating cases particularly in the case of a crude distillation unit. Inherent in these balances will be information on the fluid to be heated, the temperature entering and leaving the heater,

Specify Process Heaters

the exit pressure, and the enthalpies at entrance and exit, as well as what fraction is in vapor form at the exit conditions. This, together with the flow rate, best expressed in terms of mass flow per hour, will define the required heat absorbing capacity or "duty." This information is conveniently presented by use of a standard form, such as Figure 1, "Heater Design Data Sheet." This should identify the heater by a number, usually preceded by a letter, such as "F1." The plant and its location should also be noted. If there are more operating cases than one, there should be additional sheets for each, identified by case number.

Include Physical Property Data. The characteristics of the fluid to be heated should be given. If there is a possibility that some of it will be vaporized in passing through the heater, equilibrium flash curves should be furnished, preferably at two or more pressures. This is particularly important if the equipment is to operate below atmospheric pressure. Accompanying these curves should be the specific gravity and the molecular weights of the vapor and liquid fractions obtained for each point on the flash distillation curves.

Maximum Permissible Temperature Is Often Critical. The higher the temperature reached by the fluid, the greater is the tendency to decom-

Summary

Do you have to design or specify a fired heater for a process plant?

This article tells what kind of information is needed, and a useful form is included to summarize the design basis. It suggests maximum allowable heat absorption rates for the radiant sections and gives conversion factors for converting the absorption rate from one of the several bases in use to any other. The choice of tube sizes and spacings is discussed, as affecting the economy and absorption rates. The division of duty between radiant and convection bank is explained as a question of economic design, and the advantages of several parallel passes of smaller tubes as compared with one or a few of large size are outlined. The precautions necessary in this case to avoid instability of flow and coking are emphasized.

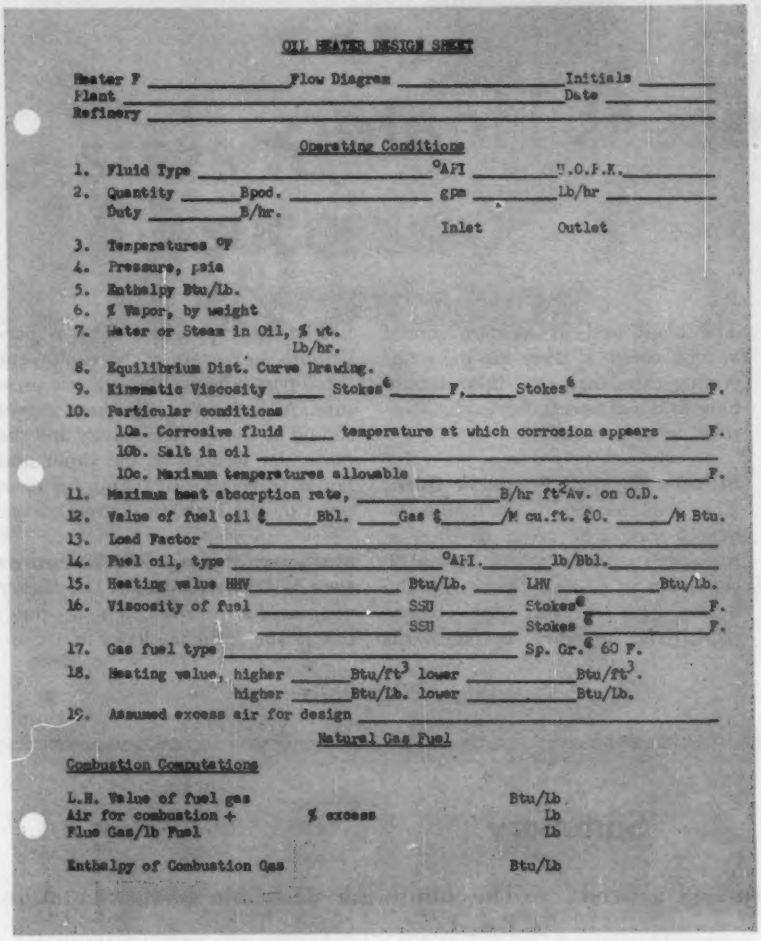
The structural frame, tube supports and hangers, and the refractory wall constructions are remarked on, as well as the burners, and the desirability of securing short flames, even at the expense of forced draft blowers, is pointed out.

The minimum desirable instrumentation is listed.

The question is raised as to whether an air preheater is justified, and the two principal types in use are described briefly. It is also pointed out that if an air preheater is included, this changes the economy of the convection section and the division of duty between radiant and convection sections, requiring the former to be larger and the latter smaller.

Stacks are discussed from the thermodynamic standpoint of available draft and friction loss, and the fact that there is an optimum combination of heat and diameter for each case is mentioned.

Reference is made to the structural problems of designing a stack to resist wind loads, which involves computing the strength of the stack to resist both bending and buckling. Finally, the important questions of vibrations of the stack transverse to the direction of the wind, as well as an ovaling vibration produced by the same causes, is covered.



OIL HEATER DESIGN SHEET

Heater F _____ Flow Diagram _____ Initials _____
Plant _____ Date _____
Refinery _____

Operating Conditions

1. Fluid Type _____ °API _____ U.O.P.K. _____
2. Quantity _____ Bpod. _____ gpm _____ Lb/hr _____
   Duty _____ B/hr.
3. Temperatures °F — Inlet — Outlet
4. Pressure, psia
5. Enthalpy Btu/Lb.
6. % Vapor, by weight
7. Water or Steam in Oil, % wt.
   Lb/hr.
8. Equilibrium Dist. Curve Drawing.
9. Kinematic Viscosity _____ Stokes@ _____F, _____ Stokes@ _____F.
10. Particular conditions
    10a. Corrosive fluid _____ temperature at which corrosion appears _____F.
    10b. Salt in oil _____
    10c. Maximum temperatures allowable _____F.
11. Maximum heat absorption rate, _____ B/hr ft² Av. on O.D.
12. Value of fuel oil $_____ Bbl. ____ Gas $_____/M cu.ft. $O. _____/M Btu.
13. Load Factor _____
14. Fuel oil, type _____ °API. _____ lb/Bbl. _____
15. Heating value HHV _____ Btu/Lb. ____ LHV _____ Btu/Lb.
16. Viscosity of fuel _____ SSU _____ Stokes@ _____F.
    _____ SSU _____ Stokes@ _____F.
17. Gas fuel type _____ Sp. Gr.@ 60 F.
18. Heating value, higher _____ Btu/ft³ lower _____ Btu/ft³.
    higher _____ Btu/Lb. lower _____ Btu/Lb.
19. Assumed excess air for design _____

Natural Gas Fuel

Combustion Computations

L.H. Value of fuel gas — Btu/Lb
Air for combustion + — % excess — Lb
Flue Gas/lb Fuel — Lb

Enthalpy of Combustion Gas — Btu/Lb

FIGURE 1—"Heater Design Data Sheet" is a form sheet that conveniently presents heater information.

pose or crack. Such cracking may make products off-color or otherwise objectionable, and might even necessitate expensive treatment or redistillation of some products. Also, in some cases, corrosion may increase very rapidly after certain temperatures are passed. It is therefore necessary to specify the maximum permissible temperature to which the fluid may be heated. Note that the highest temperature may not be at the exit of the heater but perhaps some distance back in the tubes, if the rate of pressure drop is high near the end.

The temperature must be based on experience with the particular fluid. For crude petroleum and residues, temperatures in the order of 725 F. to 750 F. are commonly given as maxima. Of course, such temperature limits do not apply when the purpose of the heater is to produce a molecular rearrangement, as in thermal cracking, reforming or viscosity breaking.

What Are the Data for Fuel and Combustion? On Figure 1 there are also blanks for the type of fuel and its heating value. This should preferably be the lower heating value, in terms of Btu per pound of fuel. Even for gas fuel, this is a better relationship than heating value per cubic foot, as it has to be put in terms of mass eventually to make the computations of air-fuel ratio.

For fuel oil, the ultimate analysis in terms of hydrogen, carbon, sulfur and any other component should be given as well as the specific gravity (or API gravity), and also the viscosity at two temperatures. This is needed to determine the temperature to which the fuel must be heated for good atomization.

For gas, in addition to the heating value, preferably the lower heating value in Btus per pound, an ultimate analysis is also useful, although there are available certain correlations of heating value and specific gravity (referred to air) that can be used in many cases. The percent of sulfur by weight should be included, unless this can be given as the mole fraction of H_2S. In the case of some natural gases there may be appreciable fractions of carbon dioxide or nitrogen, or both. It is important to note this, if so, because it not only affects the combustion characteristics and heating value but the operation of the CO_2 recorder that will be provided to control the amount of air for combustion.

Be Sure Heater Is Not a Process Bottleneck. The process heat and material balances will be used to determine the sizes of all of the various elements entering into the plant. In doing so there will be included certain intended and certain unintended margins of safety factors, particularly in the fractionating columns. First, there is always a degree of uncertainty in the design of such equipment and a difficulty exists in determining just what is the maximum limit of capacity. This is particularly the case with a new type of design or process. Next, there is a tendency for the operators to wish to protect themselves against future possible changes in specifications that will require better fractionation than they are now using. To provide for this possibility, the column may be designed with more plates and for higher reflux ratio than is presently needed. If these anticipated requirements do not happen, there is available extra capacity to make the present day products. Different possible operating cases may also provide margins here or there in the equipment. Finally, there is the point of view often held by management that a unit is a total failure if its capacity proves to be 5 percent be-

low the design capacity, but everybody is quite happy if it turns out to be 50 percent over. As a result, all provision for uncertainty must be added on top of the design basis. If the uncertainty is evaluated at, say 15 percent, the unit must be designed for 115 percent, plus or minus 15 percent, rather than for 100 percent plus or minus 15 percent. This means that frequently the column turns out to have a capacity of 130 percent or more, if all uncertainties turn out favorably. For this larger capacity the heater duty is correspondingly increased, plus a further few percent because the heat transfer equipment will not have the same favorable leeway, and the outlet temperature from the heat exchange array will be a little below the design temperature. Sometimes the designer attempts to provide for this margin by using low design heat absorption rates in the heater, but this is not sufficient. The correct way to make the design is in a carefully planned and consistent fashion, by providing a design for an increased fluid flow and duty, as well as leeway in the heat absorption rates.

The heater is one element that cannot have its capacity increased readily after it is built, as can be done by adding heat transfer area to the array or putting larger impellers in pumps. If the furnace is the limiting element in the plant, it will never be known what the maximum capacity of the column might be. It is well to be generous here.

Setting the Maximum Allowable Radiant Heat Absorption Rate. Modern fired heaters absorb by radiation 60 percent to 70 percent of the total heat absorbed in the heater, although this is influenced by the temperature at which the oil enters the heater. This still leaves the combustion gases quite hot, 1,500 F. to 1,800 F., and usually a convection section is added to recover as much additional heat as is economical. The radiant surface, including its supporting casting, refractory walls and a portion of the supporting frame and casing costs more per square foot than does the more compact convection bank. It can be shown that the cheapest over-all cost will be obtained if the radiant heat absorption rate is made as high as practicable.

TABLE 1—Conversion of Heat Absorption Rates for Tubes Spaced Two Diameters

Multiply Number ⟶ / To Obtain ↓	Absorption on Most Exposed Element	Average Absorption on Wall Covered By Tubes	Average Absorption on Circumferential Area	Average Absorption on Projected Area
Absorption on most exposed element	1.000	1.125	1.780	0.568
Average absorption on wall covered by tubes	0.8800	1.000	1.570	0.500
Average absorption on circumferential area	0.562	0.640	1.000	0.319
Average absorption on projected area	1.76	2.000	3.140	1.000

TABLE 2—Effect of Tube Spacing on Average Rate of Heat Absorption Per Square Foot of Circumferential Area

Spacing Diameters	1½	2	2½	3
Average absorption rate compare1 with most exposed element	0.465	0.56	0.635	0.68
Ratio to rate for 2 diameter spacing	0.83	1.00	1.135	1.217

The radiant absorption rate has been expressed in different ways by different investigators, as follows:

1. Btu per hour per square foot of projected tube area.

2. Btu per hour per square foot of external tube surface (circumferential area).

3. Btu per hour per square foot on the most exposed element of the tube. This is the same as the rate on an equivalent plane surface absorbing the same heat as does the tube bank.

4. Btu per hour per square foot on the total wall surface covered by radiant absorbing tubes.

Sometimes more than one of these will be used in the same reference.

The projected tube area has little to recommend it. It does not show that the total heat absorption depends on the tube spacing.

The absorption on the circumferential area is the most commonly used method. However, this also does not show the effect of tube spacing. It is, furthermore, quite misleading if there are two rows of tubes, one behind the other.

The absorption rate on the most exposed element is the method that determines the maximum absorption rate, and the one that must be used to make the radiation heat balance. This is the basic design criterion.

The absorption per square foot of wall surface behind the tubes is useful for determining the amount of furnace wall that must be covered with tubes.

However, for a given spacing of tubes in terms of diameter, these rates are mutually interconvertible. Table 1 gives such a table for tubes spaced two diameters center to center. Similar tables can be made for other spacings using the data of Hottel.[1]

How is the maximum permissible absorption rate determined? The maximum permissible heat absorption rate is determined by experience with the particular fluid being heated, in a furnace of similar design. The limitation is the rate at which the thin film of oil next to the hottest side of tube begins to crack and deposit coke. This depends on the nature of the fluid being heated, the average temperature of the fluid in the tubes, and on the fluid velocity. A higher radiant heat absorption rate can be permitted with colder fluids and higher velocities. In steam boilers, rates of 60,000 Btu/hr ft² are not uncommon. Some data reports up to four times this rate, with exceptionally pure, silica free water. The companies that design heaters have in the past recommended radiant absorption rates of 12,500 to 15,000 Btu/hr ft² of circumferential tube surface. In recent years rates up to 17,500 Btu/hr ft² have been offered. In practice rates up to 50 percent higher than these are not uncommon.

For thermal cracking and reforming service, the tubes are operated with the expectation that coking will occur, and the firing rate is reduced

as the temperatures of the tubes rise. The highest radiant absorption rates I have seen have been in thermal cracking heaters, although to attain them, cores were placed in the tubes that were first found to become overheated. This caused an increased velocity and delayed the "coking-up."

In making the heater design it is usually assumed that the heat absorption in the radiant section is uniform. Actually this is not so, but the tubes nearest the burners receive more radiation. If the coldest fluid is passed through these tubes that are most exposed, the heater will have a higher capacity.

Does the type of fuel affect the maximum permissible radiant absorption rate? The answer to this is no. This maximum is determined by the condition *inside* the tubes, and the heat released per square foot of radiant absorbing surface can always be adjusted in the design to give the maximum permissible rate that has been found satisfactory. While the performance of a given heater might be somewhat different with fuels ranging from say, methane, to a heavy fuel oil, the difference is much less than some of the published articles indicate, and heaters are often operated interchangably on natural gas or fuel oil. Inspection of the radiant absorption rates in the extensive test data of Lobo and Evans[2] shows high rates for both fuel oil and gas.

What is the best tube spacing for the Radiant Bank? Return leaders are available with minimum center to center distances of the tubes from 1½ to 2 diameters, depending on the tube size and pressure ratings. Maximum tube spacing for standard headers are 2½ or 3 diameters.

The average absorption rate per square foot of circumferential area increases with the tube spacing as shown in Table 2. This table shows that six tubes spaced 1½ diameters on centers and covering nine diameters width of wall will absorb the same amount of heat as 5 tubes spaced two diameters and covering 10 diameters width of wall. It is then a question as to whether the saving of one tube and its header amounts to more than the cost of the wall section of one diameter width. In general it is more economical to use the two diameter spacing. If the tubes are of more expensive alloy than carbon steel, such as chrome-nickel, an even greater spacing will be economical.

Double rows of tubes are not economical. It was formerly quite common to have double rows of tubes on the walls of heaters. Nelson[3] appears to favor this. He points out that a single row of tubes spaced two diameters acts as though it covered 88 percent of the wall, while a double row acts as though it covers 98.6 percent. He fails to carry this to the logical conclusion that two rows cost twice as much for tubes and headers and only absorb 12 percent more heat. I have seen no recent heater designs with double rows of tubes on the walls.

How is the tube diameter chosen? For a given working pressure, the cost of a tube varies approximately as the square of the diameter. Return headers, being geometrically similar, vary in weight and cost approximately as the cube of the diameter. For a given total surface, smaller tubes are obviously cheaper. On the other hand the pressure drop per unit length varies as $1/D^5$. To be able to use smaller diameter tubes and have a reasonable pressure drop, it is necessary, usually, to have some passes in parallel.

Figure 2 shows how the diameters and lengths of tubes vary with the number of passes for arrangements all having the same total area and over-all pressure drop. If the length is L, and the diameter D, for a single pass, for n passes the length of each pass would be $L_n = L/\sqrt{n}$ and the diameter $D_n = D/\sqrt{n}$. The total weight of the tubes would be proportional to $1/\sqrt{n}$ for n passes as compared with a single pass. Thus the cost of the tubes for four passes will be half that for one pass. These relations are, of course, approximate, since they are, in effect, based on the inside diameter for pressure drop while the weight is closely approximate to the inside diameter plus the tube thickness. Also, no account is taken of the extra thickness that may be included for corrosion allowance.

Tube passes. Because of some unfortunate experiences with coking-up caused by flow instability, there was formerly a prejudice against parallel passes, and many furnaces were designed that had pressure drops in the hundreds of lbs. per square inch. Now that the causes of these difficulties are known, it is no longer necessary to have very large pressure drops. Even for rather large

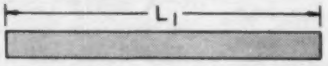
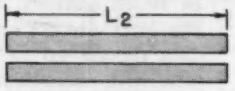
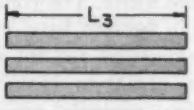
Number Of Parallel Passes	Arrangement	Diameter	Length
1		D_1	L_1
2		0.707 D_1	0.707 L_1
3		0.576 D_1	0.576 L_1
4		0.500 D_1	0.500 L_1
n		$\frac{D_1}{\sqrt{n}}$	$\frac{L_1}{\sqrt{n}}$

FIGURE 2—Relations between diameters and lengths of tubes to give the same total areas and over-all pressure drops with different numbers of passes in parallel.

heaters, this can be kept in the range of 100 psi. To avoid trouble the following precautions are essential.

- The velocity of the fluid should be kept fairly high in the convection section so that a considerable fraction of the pressure drop will occur in the tubes where no evaporation may be expected. This has a dampening effect on any tendency to unstable flow.
- There should be as many parallel passes in the convection bank as there are in the radiant bank at the point where they join. (Each pass in the convection bank may consist of two parallel passes for each one in the radiant bank.)
- There should be no further branching of passes in the radiant bank, up to the point where vaporization starts. Branching into additional parallel passes may start there, as required by the increasing volume, but this branching should be like that of a geneological tree with no cross connections between the cousins. There should be no cross connections between the parallel passes except at the beginning of the convection bank and the end of the radiant bank where the transfer line or lines connect.
- The practical difficulty is to arrange the passes so that each pass has as nearly as possible equal exposure to the radiation in the combustion chamber. It is easy enough to have one pass up each side wall of a heater, branching to four on the roof. By the use of jump-headers, two parallel passes can be placed on each side of the two sidewalls, possibly branching to a total of eight on the roof. With tubes on the floor, two side walls, and roof, four, or possibly eight parallel passes can be installed in a rectangular heater of square cross section. Various types of cellular arrangements have also been used. Multiple passes can also be arranged readily with vertical tubes in a cylindrical combustion chamber or with vertical tubes in a cellular arrangement.

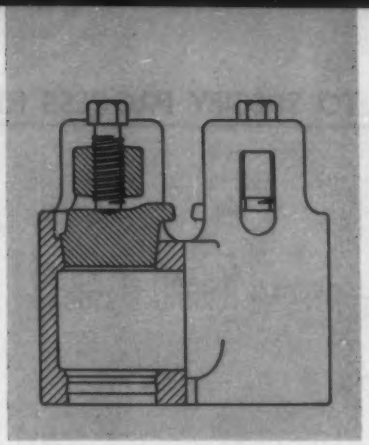


FIGURE 3—The "mule ear" type return tube header is the most commonly used in the process industry.

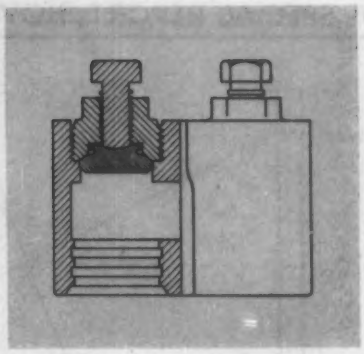


FIGURE 4—A modern "screw lock" return header is based on an original crude design by The M. W. Kellogg Co. in 1927.

How to compute pressure drop if there is vaporization in the tubes. If some of the fluid is vaporized in passing through the tubes, which is common and even desirable to keep the maximum temperature down, the computation of the pressure drop is somewhat more complicated than with liquid phase alone. In most cases (except for vacuum operation) this is most easily done by Ludwig's method (this is described in the author's paper "Flash Flow Pressure Drop In Heaters" published in the November, 1955, issue of PETROLEUM REFINER).

Tendency is to design for long tubes. The cost of the return headers is usually more than the cost of a tube 30 or 40 feet long. For this reason there has been a tendency to design heaters with longer tubes, 60 feet or more, to save header costs. There are some disadvantages in this, as the convection bank, which is frequently placed on top of such heaters, also gets long, and it is difficult to get the flue gas velocity high enough to obtain a reasonably high transfer factor.

Return tube header types. The tubes of a heater are connected in series by return bends. In some cases where it is known that cleaning will not be required, welded return bends may be used. Generally, however, each tube will have a header at one end that will have a removable plug to permit cleaning. If much cleaning is required, removable plugs will be provided at both ends of each tube.

The most commonly used header of this type is the "mule ear" type, shown in Figure 3. This is available from a large number of manufacturers in a wide variety of sizes, materials, and pressure ratings. There is one disadvantage of this type of header for very high temperatures. The plugs generally have a rather small taper to facilitate getting a tight seat. The central screw, however, can easily become hotter than the mule ears because it is fairly well surrounded, and the mule ears can more readily lose heat and remain cooler. The differential expansion on this account may develop rather large stresses which force the plug into the body, gradually enlarging the seat. The same forces have also been known to cause shearing of the acme threads on the central screw.

Another type of header is the so-called "screw-lock" type, as shown in Figure 4. The plug in this header has a rather flat bevel (like a globe valve) instead of a sharp conical form, and the screw is in a position where the temperature differences are less than in the mule ear type. This header has been somewhat more expensive in the past, but with increased production perhaps the cost difference will decrease.

Special, streamlined plug types can be obtained, which, together with a smooth flow passage in the header body, results in a lower pressure drop than the usual header. These cost more, and have the disadvantage that the plugs can easily become cemented in place by coke and becomes difficult to remove. It is probably true that if the pressure drop in the header is so high that the extra cost of this type is justified, it is probably also uneconomically high in the tubes as well.

Therefore, it would be better to

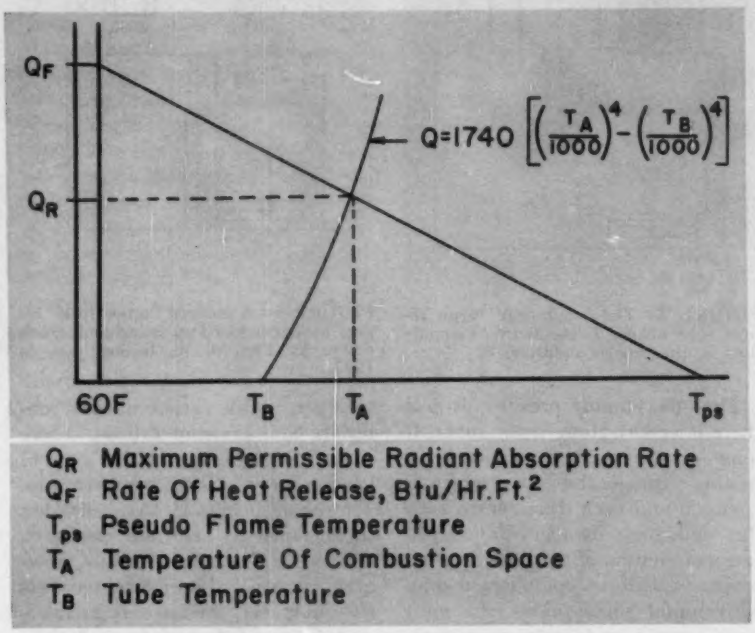


FIGURE 5—Use this original author's chart to find the temperature of the combustion space.

reduce the velocity by larger tubes or more passes.

Groove specification. Tubes are generally rolled into headers. There are various types of grooves used in the tube seats to secure a tighter and firmer attachment with a minimum amount of distortion in the rolling process. If you have other heaters in your plant, you will probably wish to specify the type of groove to conform to your standards, to facilitate maintenance.

There has been some development in welding tubes to headers. This in general can only be done on one end of the tube because of lack of room to do the welding with the tube in place. A pair of tubes is made into a hairpin by welding to a header, and the opposite ends are rolled into headers of the roll-in type.

How are the gas temperatures and division of duty between radiant and convection sections computed? The temperatures at various places in the heater are computed step by step as follows:

1. Take as a basis one square foot of radiant absorbing surface in the heater. This should be a square foot of the equivalent plane surface. The rate of heat absorption on this surface will be the same as that on the most exposed element of the tube. Decide on the basis of the fluid heated and its temperature, what the maximum permissible radiant absorption rate will be for the design. Call this Q_r.

2. Estimate the temperature on the outside tube surface. This will be the fluid temperature plus the temperature difference through the tube walls plus whatever fouling resistance experience indicates. This should be computed for the most exposed element.

3. For this tube surface temperature, plot a curve showing the furnace temperatures required to give particular rates of heat transfer by radiation, using the Stefan-Boltzmann law:

$$Q_r = 1740\left[\left(\frac{Ta}{1000}\right)^4-\left(\frac{Tb}{1000}\right)^4\right]$$

Where

Q_r = Btu/hr ft² on most exposed surface
T_a = Furnace Temperature, in degrees Rankine = Degrees F + 460
T_b = Outside Tube Surface Temperature, Degrees Rankine

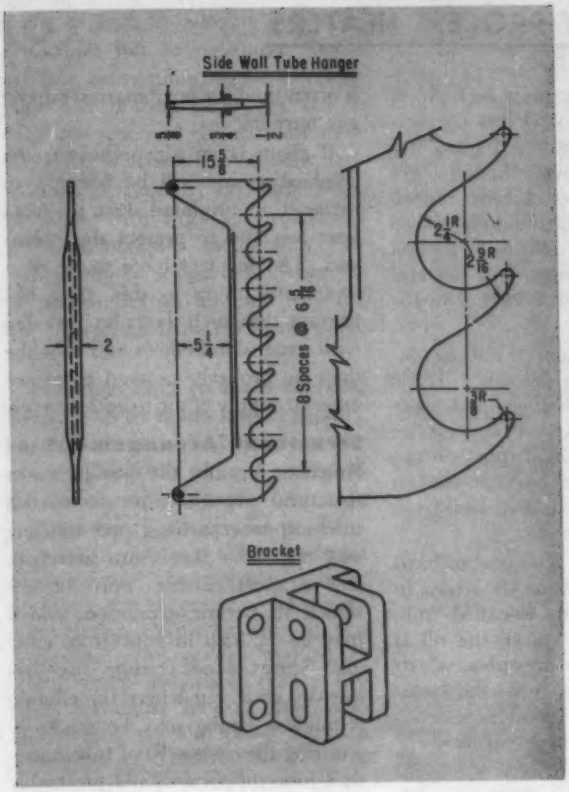
(Note that the absolute temperature is used in this computation, but it will be convenient to plot it in terms of degrees F.)

Lobo and Evans describe such a chart (see Figure 5) but in their presentation they include an allowance for the heat absorbed by convection on the tubes in the radiant section and also divide by a coefficient ϕ to take care of the difference in radiation from gases and black bodies, the average beam length of the radiation through the gases, a shape factor, and the fraction of the combustion chamber walls that is refractory rather than absorbing surface. They actually plot Btu/hr ft² found as the sum of the radiation by the Stefan-Boltzmann law and the convection, divided by the factor ϕ. In effect, this means that their chart predicts that the gas temperature will be somewhat higher to produce a given rate of radiant absorption than would be given by the Stefan-Boltzmann law.

I have found by computing a considerable number of the test data given in their paper for the usual box type heater that I can get a good correlation of temperatures and absorption rates by using the Stefan-Boltzmann curve, neglecting the heat absorbed by convection, and taking $\phi = 1.0$ (in effect, ignoring this also). This makes a considerably easier computation, and the gases in it combine to act as though they constituted a black body at the temperature of the outgoing gases.

4. On this curve, plot the maximum heat absorption rate that has been chosen for design, expressed in terms of Btu/hr ft² on the most exposed surface, which is the same as the absorption rate on the equivalent cold plane surface A_{cp} in the Lobo and Evans paper. The two co-ordinates of this point are the combustion chamber temperature and the heat absorption rate in Btu/hr ft² on the most exposed surface.

5. For this temperature, and for the lower heating value of the fuel and the amount of combustion air, including excess chosen, compute the pseudo-flame temperature (See Lobo and Evans again), and plot this on the zero ordinate. Draw a straight line back through this point and heat absorption value plotted on the curve, until it intersects the line of



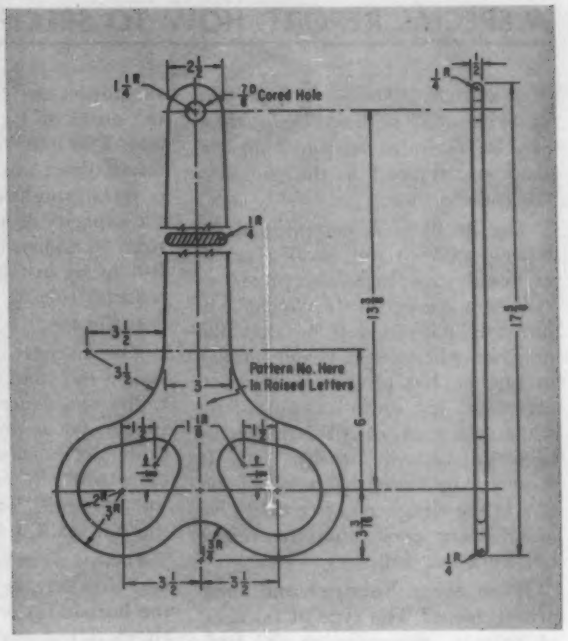


FIGURE 7—Typical roof tube hangers (shown above) are also spaced 10 feet on centers.

FIGURE 6—Typical side wall tube hangers and brackets (left) for 3½-inch tubes are spaced approximately 10 feet on centers.

atmospheric temperature (conventionally, 60F). This will give the Btu/hr ft² that must be released. Call this Q_t. Then Q_r/Q_t is the fraction of the heat released per square foot per hour that is absorbed by radiation.

6. The temperature of the combustion chamber found in Step 4 will usually be in the range of 1,600 F. to 1,800 F. This still leaves about half of the heat of the fuel in the gases. It usually is economical to add a convection section to recover some of this heat. This must be determined by an economic balance, taking into account the value of the heat, the transfer factor, the cost of the surface per square foot, including a proportionate cost of the headers, and the payout period. This may indicate that it will be economical to recover 70 to 80 percent of the heat available from the range of the combustion chamber temperature down to the entering oil temperature. Call this amount of heat Q_c. The total heat absorbed in both radiant and convection sections is then $Q_r + Q_c$ and the overall furnace efficiency is then

$$E = \frac{Q_r + Q_c}{Q_t}$$

For each square foot of radiant section plus the convection section the heat absorbed per hour is $Q_r + Q_c$. The total square feet of radiant surface is obtained by dividing the total duty by $Q_r + Q_c$. The surface thus found is the equivalent plane surface having the same radiant absorption as the most exposed element of the tubes. This can be converted into other forms by applying the factors from Table 1. Having found the overall efficiency, the fuel rate and the weight of the combustion gases can be computed. The convection bank can then be designed by conventional methods.

Details of the convection bank. It is often difficult to get an arrangement of the convection bank that will have the relatively high gas velocity required to give a reasonably high transfer factor. For the convection bank, the headers should have centers as short as possible and still permit nesting the headers at 60-degree angles. Usually this requires at least 1½ diameter spacing. The bundle may be made more compact by using smaller tubes, with two or more tubes in parallel for each pass staring the radiant bank. This will also be cheaper for a given area. Generally, the convection bank should be deep in the direction of the gas flow and narrow transverse to the flow. To give a general idea of the gas velocity required, a velocity of 25 feet per second will give a transfer factor of about 6.3 Btu/hr ft²/°F with 4 inch tubes spaced on 8⅜ inch centers, staggered.

How should the tubes in the radiant and convection sections be arranged? There are many possible arrangements of tubes in the radiant bank. The tendency here is to approach the practice of large steam boilers and completely surround the combustion chamber, as nearly as possible. (Large boilers today commonly have all walls, roof and bottom covered with tubes.) Because of the necessity of having headers with plugs removable for cleaning, this is more difficult for process heaters. There must be space to put in burners and space for the gases to pass to a separate convection bank. The usual form for large heaters is a rectangular box, but there have been some quite large heaters built in the form of an A frame with the convection bank on top. Smaller heaters are economically built in the form

of a vertical cylinder. In capacities up to about 20 million Btu/hr, these can be entirely fabricated in the shop and shipped to the site as a fabricated unit.

The problem is complicated by having to keep the parallel passes as nearily uniformly exposed to radiation as possible. What will probably happen will be that the designer will offer a heater similar to one he has previously designed for about the same capacity, on which the many small details have been satisfactorily worked out. It is better to leave the initiative on this to the designer rather than give an arbitrary specification that might not work out well.

What about burners and their arrangement? The type of burners, of course, depends on the fuel, whether oil or gas, or both. Furnace capacity is often limited by flames licking the tube, causing hot spots. A short flame is always desirable on this account. A large number of smaller units is desirable, and this may even permit the use of a smaller combustion chamber. To obtain short flames, the velocity through the burner register must be high, of the order of 40 to 60 feet per second. This may requires the use of a forced draft fan even though there is no air preheater. I have known the capacity of a heater to be raised from 38 million Btu/hr to 52 million Btu/hr by installation of a fan and reduced register diameter in the four burners.

The burners should not be installed too close to the tubes. Three to five feet depending on the burner size should be provided between the centers of burners and tubes on the same wall. Where burners are on the end walls, about five feet from the side walls is good.

Fuel oil must be atomized to burn and this may be done by steam in the burner tip or by so-called "mechanical burners" where the oil is brought in at high pressures, which furnishes the energy to do the atomizing. I have had good experience with this type on large burners.

Gas burners may have a central tip that may be interchangable with an oil burner, or may be a ring with numerous holes surrounding the burner refractory orifice. This type is often used for combination oil and gas burners.

If there is an air preheater, the combustion air will be brought in through an insulated duct to avoid heat loss and to protect the operators. The burners have to be of a type conforming to this. It is important that such ducts be provided with expansion bellows and that the duct be properly tapered to insure an even supply of air to each burner.

Structural Arrangement of Heater. Usually the heater has a structural steel frame to which tube support castings and hangers and end tube sheets are attached. The support castings must be designed to permit expansion, which may be ¾ inch in a five-foot casting. Sheet steel casings are frequently used, but where the climate is mild, a saving may be made by omitting the casing. Roof tube hangwall tube supports should preferably holding not more than two tubes each, to avoid stresses and warping caused by unequal temperatures in different parts of the hangers. Side wall tube support should preferably be of the open hook type. This is better than having a web on the hot side, as this gets hotter than the portion behind the tubes and tends to warp. The material must have a high strength at high temperatures, 25-12 chrome nickel being commonly used. In many cases the designs have been unnecessarily heavy, and this material is expensive. Intermediate hangers spaced about 10 feet apart are close enough. Some typical designs are shown in Figures 6 and 7.

At the ends of the heaters, tube sheets are provided through which the tubes pass outside the combustion chamber to a header compartment. There are generally cast iron with plastic refractory facing on the fire side. They are made in sections to hold, say, 5 or 6 tubes, and are bolted to the structural frame by ribs or flanges. These connections should also have slotted holes to permit expansion.

Convection bank intermediate tube supports are also usually of heat resisting materials, but not neces-

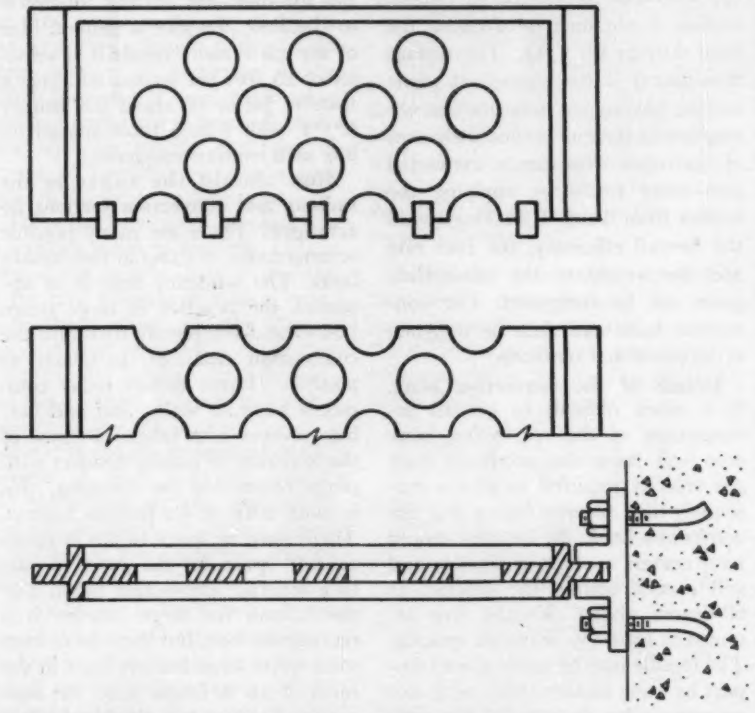


FIGURE 8—Channel shaped guides are used for convection bank intermediate tube supports.

sarily as high in alloying elements. It is best not to use large sheets holding many tubes, as the portions near the hottest gases get hotter than the rest and the castings tend to warp. A series of relatively narrow plates, holding, say three rows of tubes, with lugs to facilitate stacking, makes a satisfactory job. These may be supported in channel shaped guides on the side walls of the convection bank enclosure (Figure 8).

End tube supports for convection banks may be made larger, as they can have refractory facings on the hot side, and do not get as hot as the intermediate supports.

Refractory walls have a mild exposure. The walls of the combustion chamber and the convection bank enclosure are generally of refractory construction, usually one of the numerous proprietary designs, in which there are many relatively small refractory blocks, often with interlocking grooved faces, that are supported on castings which are in turn supported on the steel frame. All of the details of these refractories and their supporting means are worked out by the suppliers of the refractories.

As compared to large steam boilers, the temperatures in process heat are relatively low, and refractories suitable for the very highest temperatures are not necessary. Refractories of the insulating type are available, that have a much higher resistance to heat flow than solid firebrick and these permit the use of thinner and lighter walls and roofs. A certain amount of plastic insulation is placed over the outside of the refractory walls and roof, partly to act as a seal to prevent air being drawn through the walls by the lower pressure inside the combustion chamber. The amount of such insulation has to be limited so the castings that support the walls and roof are not exposed to excessive temperature. If there is no steel casing, this plastic may in turn have a seal-coat containing asphalt, generally included as an emulsion.

Provide anchorage for transfer lines. Where the radiant tubes discharge into a header connection to the column transfer line, a solid anchor attachment should be made to the heater frame. This prevents transfer line expansion forces from being applied to the furnace tube bank and shoving the tubes around.

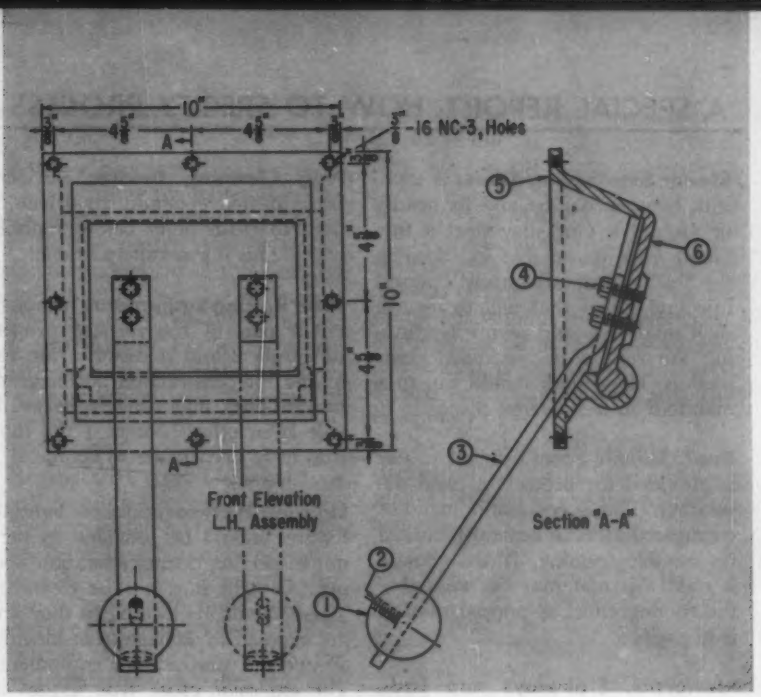


FIGURE 9—Simple design peep hole opens inward.

Precautions for the foundation. Usually the heater will rest on a concrete foundation. This may be a slab, if the soil bearing pressure is good, or it may be supported on piling, with the slab supported by concrete beams. If the floor of the combustion chamber is practically at ground level, some means of ventilating and cooling the top of the slab should be provided. No amount of insulation under a refractory floor will prevent the slab becoming overheated with resultant calcination of the concrete, unless there is a means for actually removing the heat that passes through the refractory floor. A layer of hollow tile, laid end to end to form air ducts under the floor, will do this. Care must be taken that the ends of these ducts are not blocked where the columns are anchored to the slab. The end nearest the stack can have a duct connected to the stack or to the inlet of the forced draft fan, to produce the necessary current of air through the floor ducts.

MISCELLANEOUS ITEMS

Header Compartments. The return headers extend into a header compartment box provided with hinged covers and latches. The inside of these boxes should have a couple of inches of plastic insulation to maintain uniform temperatures in the headers and reduce heat loss. There should be about 1½ inches clearance behind the headers, so that with the use of a mirror the tightness of the rolled joint into the header can be checked during the hydrostatic test.

Be sure there is enough clearance between the header and the door to permit expansion of the tubes when they are heated. This might be as much as 6 inches.

Peep Holes should be provided through the refractory so that all of the exposed sides of all of the tubes in the radiant section can be inspected to detect formation of hot spots. This usually requires a number of peep holes. A simple design for a peep hole door is given in Figure 9. The door opens inward and is made of a heat resisting alloy, with the frame of cast iron. A flared opening must be provided in the refractory walls to permit the required angle of view.

Manway Doors. One or two manway doors, with cast iron frames, should be provided to permit entrance into the combustion chamber. Refractory bricks are piled in front of the doors before they are closed.

Steam Smothering Lines. A small leak between a tube and its header or around a plug may start a fire. Small lines to suitable locations in the header compartments will permit injecting steam that will extinguish such small fires and permit continuing the run to its scheduled completion. These lines should run to a manifold in a sheltered place.

Roof. Usually a roof over the heater is provided for protection from the weather. This is commonly made of corrugated asbestos cement mounted on suitable framing. If the climate is mild this roof may be omitted—the cooling effect of normal rainfall is negligible.

Platforms, Stairways and Ladders. Suitable platforms must be provided for access to all headers for inspections and cleaning of tubes. For tubes on the side walls this sometimes makes a problem. Movable platforms have been used; or racks across which planks may be placed at intervals of about two feet have been used—these are cheaper. Platforms should be 4 or 5 feet wide to provide room for the men operating the tube cleaners. They should, of course, be provided with safety handrails. A stairway rather than ladders to elevated platforms is convenient to facilitate carrying up the heavy tube cleaners and hoses. If a stairway is not provided, a small jib crane will be useful to hoist such equipment. It is desirable to see that the design of the stairs and handrails conforms to the refinery standards. Rise and tread of the stairs, in particular, should conform, because one get habituated to a usual pattern.

Air Supply for Tube Cleaners. Piping and quick-detachable connections for air for tube cleaners should be provided at convenient points. Generally, this piping can be attached to the handrail posts. It may even form the mid-rail.

Racks for Plugs. It is convenient to have racks into which the plugs and holding members can be placed as they are removed.

Plug Cleaning Device. A wire-brush device, generally air driven, is used to clean plugs before replacement. This is generally portable.

Tube Rolling Equipment. Although not a part of the furnace proper, tube rollers and accessories are required for construction and maintenance. They may already be available from other heaters if the tube sizes have been made to conform.

Lighting Fixtures. Suitable lighting fixtures should be provided to permit inspection during operation and provide light during tube cleaning. These should be located so they are not exposed to damage from moving around the tube cleaning equipment. The explosion-proof type fixture is sometimes used, but the protective grill over the glass makes it difficult to keep clean. The vapor-proof type with heavy glass enclosure is more satisfactory from this point of view.

MINIMUM INSTRUMENTATION

For temperatures on the air system. Thermocouple points and indicator for: Atmospheric temperature, out of air preheater, bridge wall (entrance to convection bank), exit gas from convection bank, and flue gas out of air preheater.

For temperatures on oil side. Thermocouple points and indicator for: Oil into convection bank, oil out of each pass on convection bank, oil out of each pass of radiant bank, and temperature at entrance to transfer line to column.

For tube skin temperatures. A number of points on tubes expected to be critical.

Temperature of fuel oil to burners.

Draft gages. Entrance to air preheater in cold side, exit from air preheater on cold side, at selected burner locations, on outside of register, in combusion space, at burner elevations, in combustion space, at point under roof, at exit from convection bank, at exit of air preheater hot side, at exit of induced draft blower, and at stack breeching.

Pressure gages. Oil into convection bank, oil out each pass in convection bank, oil out each pass in radiant bank (for test purposes, additional gages as needed), and fuel to each burner.

Fuel meters. For oil, a positive displacement type meter to give totals plus an orifice type to give instantaneous rate.

For gas, an orifice meter.

CO_2 Recorder. To determine the percent CO_2 in the flue gas from which the air-fuel ratio can be determined. This instrument permits operating with minimum excess air.

Automatic temperature control. If the heater is of appreciable capacity or in critical service, automatic control of the fuel rate is desirable. This is usually arranged to control the temperature of the fluid heated and maintain it constant. A thermocouple in the transfer line at the heater end will give the indication, and the controller will regulate the fuel rate. For maximum efficiency the air rate should also vary with the fuel rate, but this makes the installation much more complicated. It is seldom done on process heaters, although it is common on large steam boiler installations.

At one time it was necessary to have considerable amounts of excess air to avoid over heating the radiant section tubes. This was before the designers knew how to design properly for radiation. Now, it is practical to design and operate a heater with a negligible amount of excess air. However, to avoid having to adjust the air rate with the fuel, it is usual to deliberately provide 25 or 30 percent excess air. This permits the fuel rate to vary up to the same excess over normal without producing smoke. Thirty percent excess air involves a loss in efficiency of about 3.5 percent if the stack temperature is 700 F.

Automatic fuel cut-off. There should be a provision for automatically cutting off the fuel to the heater on the occurrence of any one of the following emergency conditions:

1. Failure of electric power.
2. Failure of cooling water supply.
3. Excessive pressure in fractionating column.
4. Excessive temperature in transfer line from heater.

This device should require manual reset, after the condition causing the shut-off has been corrected.

IS AN AIR PREHEATER JUSTIFIED?

If the oil enters the heater at a high temperature, it follows that the flue gas temperature will also be high. If the amount of heat carried up the stack is great enough, it may be economical to recover some of this heat by means of an air preheater, thus saving fuel.

Types of Air Preheaters. There are two principal types of air preheaters in use.

Tubular type. This type consists of a bundle of parallel tubes in a case. The hot gas usually passes through the tubes and the fresh air back and forth across (or parallel to) the tubes. The tubes are small and thin compared with those for oil in the convection bank. They are usually only large enough to permit cleaning easily, about 1½ inches in diameter and 16 or 14 U.S. gage. The bundles are compact. This makes the cost of this surface only a fraction of the convection bank on a square foot basis. The cost per unit of heat transferred is less on this account, in spite of the fact that the over-all heat transfer coefficient is only about half as high as in the convection bank because there are two gas films to pass through. The question thus arises as to whether, once having decided to install an air preheater, it would not pay to reduce the size of the convection bank and transfer even more heat by the air preheater. Studies along these lines indicate that this is indeed desirable, and is limted only by the maximum temperature that is desirable to bring the flue gas to the air preheater. This is about 1,100-1,200 F. Above this temperature the tube sheets in the air preheater may start to burn out.

One point should be checked. In very cold weather, or at a lower than normal rating, it is possible to cool the tubes on the cold end below the dew point of the flue gas. If there is any sulfur in the fuel, there will be a formation of sulphurous and sulphuric acids on the tube surface, with very rapid corrosion.[5] To prevent this, a steam heating coil has sometimes been used at the cold air entrance.

Where a heater may have a relatively low rating for some operating cases, it may be preferable to use a parallel-flow heater design rather than counterflow, as in this case the metal wall does not get to such a low temperature. This type of heater is not so efficient, but it may easily have an economic efficiency as high as a counterflow unit that has its area reduced to prevent too low temperatures.

Regenerative type. The other type of air preheater, which has been used principally in boiler installations, is the Ljungstrom regenerative type. This consists of a large disk made of metal with radial and circumferential fins, which revolves slowly on an axis. At one side, the disk passes through a hot gas passage. The gases pass through it and heat up the metal. The disk turns continually and then passes through a cold air passage and gives up its heat to the incoming fresh air.

Effect of air preheater on the division of duty between radiation and convection in the process heater. While the air preheater makes it economical to reduce the size of the convection bank, the heat transferred to the fresh air is equivalent to having a lower fuel-air ratio and it is necessary to add surface to the radiant section to prevent exceeding the allowable heat absorption rate. The graphical design method mentioned previously can easily be modified to take care of the case of preheated air by moving the pseudo-flame temperature and the entering air temperature to the right an amount corresponding to the air preheat.

Effect of air preheater on the stack. An air preheater also has an effect on the requirements for the stack. It simultaneously increases the draft requirements and lowers the stack temperature and its draft producing ability. The answer is to put in an induced draft blower, to force the fresh air through the preheater, ducts and burners. The objective is to keep the pressure near the roof of the combustion chamber as nearly balanced with the atmospheric pressure as possible, to minimize hot air leaking out or cold air leaking in. This permits reducing the stack height to the minimum required to discharge the gases where they will not constitute a nuisance.

STACKS

The stack must be large enough in diameter to handle the maximum amount of flue gas as produced by the heater without excessive friction loss and discharge it at a sufficient height that it will not constitute a hazard or annoyance on adjacent equipment.

The available draft for a stack of diameter D feet and height H feet may be computed by the following formula.

$$P_a = 0.0765\left(1 - \frac{529}{T}\right)H - \frac{0.0251\,M^2\,(H + D/f)}{\rho\,D^5}$$

Where

- P_a = available draft in terms of Lb force/ft² (1 lb_f/ft^2 = 5.2 inches of water)
- T = Temperature of stack gas, degrees Rankine = Degrees F + 460
- H = Stack height in feet.
- M = Mass flow rate of flue gas, lb_m/sec
- ρ = Density of flue gas at its temperature, lb_m/ft^3
- f = Friction factor in Darcy-Weisbach flow formula. This will be about 0.016
- D = Diameter, ft.

The first term is the static draft. The next term is the friction loss and velocity head loss. D/f is the length of stack that would have a friction loss equal to one velocity head.

A minimum height is required to produce a given draft with a large diameter. For a smaller diameter the friction loss will be greater, as well as will be the velocity head loss of the moving gases leaving the stack, and to produce the same net draft the stack must be made higher to compensate. There is one combination of height and diameter that will cost the least.

It is also possible that the height of the stack may be limited by the Civil Aeronautics Authority if the location is near a city with an airport.

What Material Should Be Used?

The cheapest stack is a simple cylindrical pipe of sheet steel. The stack need be only one-quarter to five-

sixteenths inch thick for heights up to 200 feet. A concrete stack, including its heavier foundation, may cost as much as $50,000 more than a steel one for 9 feet by 180 feet.

There is no advantage in having a conical flared section in the lower portion. It costs more and makes it harder to compute the natural frequency of vibrations.

A steel stack should preferably have about 1½ inches of plastic insulation on the *outside* surface, to keep the metal hot so condensation of acid bearing moisture does not occur that would cause rapid corrosion. This also prevents heat loss that cools the gases and reduces the draft produced, and the capacity. Computations made on a 9 ft. x 180 ft. stack indicated that the temperature of the gases might drop from 600 F. to 440 F., a drop of 160 degrees, with a cold wind of 40 miles velocity past the stack on a cold day, if the stack were not insulated. This would reduce the maximum capacity of the heater about 4½ percent, if draft were the limitation.

Structural and Aerodynamical Considerations of a Stack. A tall stack is subject to a considerable bending moment by direct action of the wind. For usual structures, wind loads are commonly taken at 15 lbs/ft² for heights up to 60 feet and 20 lb/ft² for higher areas. For a cylinder, the flow is smoother and the resistance less. It is usual to compute the drag force on the basis of the velocity pressure:

$$Pu = C\frac{\rho u^2}{64.34}$$

where ρ is the density of the air in lb/ft³, u is the velocity in ft/sec. Pu is the velocity pressure in lb/ft² and C is the drag coefficient. For large values of Reynold's Number, C has a value of about 0.35. Applying this,

$$Pu = 9.00\left(\frac{V}{100}\right)^2 \text{, lb/ft}^2$$

where V is the velocity in miles per hour.

A force of 15 lb/ft² on the projected area of a cylinder corresponds to a wind velocity of 129 lb/ft² which is high enough to be improbable in most locations.

If the stack has no guy wires, a large and massive foundation is required. The stack has to be designed to resist the bending moment. Its strength must be computed for failure by bending, which would involve yielding in tension on the side toward the wind, or by buckling, which would occur on the compression side. Methods of computation may be found in Timoshenko's "Theory of Plates and Shells."[6]

In addition to bending away from the wind, a steady wind causes vibration transverse to the wind direction. This is caused by the formation of eddies on the lee side of the stack, that break off alternately on each side, resulting in sideways impulses. The frequency of these eddies is proportional to the product of wind velocity and stack diameter.

An unguyed stack has a natural frequency of vibration as a cantilever that depends on its diameter, thickness and height. There will always be a wind velocity that produces impulses that will be in resonance with the natural frequency of the stack. When this occurs the oscillations tend to build up to large amplitudes. This may cause cracks or complete failure. There are a number of examples of such cases in the literature. The wind velocity to cause these oscillations may be only a fraction of the wind velocity required to produce collapse by direct bending in the direction of the wind.

The same pulsating forces also produce another oscillatory effect. This is to produce a flattening or ovaling of the circular cross section to an ellipse with the major axis in the direction of the wind, changing back to circular section and then to an ellipse with the major axis transverse to the wind. This flattening may be 4 or 5 inches in a 6½-foot diameter. It tends to produce stress concentrations at irregularities in the shape or at weld intersections. The stack can be stiffened against such ovaling oscillations by welding stiffening angles around it at intervals of about one diameter.

Operators frequently object to having guy wires around their areas, but if you are persuaded to leave them off, the chances are very good that you will have to come back later and put them on and be blamed for not having insisted on putting them on in the first place.

If guy wires are put on and it is possible to locate their anchorages symetrically, it should be noted that three guy wires are as effective as four, as can be shown by a simple stress analysis, and cost only 75 percent as much.

In any case, the breaching connection into the stack should be provided with bellows so minor movements do not start cracks at the intersection, which is always a place of stress concentrations. This intersection, incidentally should be reinforced along the lines used for openings on pressure vessels.

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About the Author

Frank L. Maker is a Fullbright Professor at Institut Francais du Petrole, Paris, where he has also been a professor and consultant for a year. After receiving a degree in architecture from the University of California, he joined Standard Oil Co. of Calif. as a structural engineer. There he served as designs engineer at the Richmond, Calif., plant and in the Manufacturing department as secretary of the board of consulting engineers. For a year he was acting designs engineer for Arabian American Oil Co.'s Ras Tanura, Saudi Arabia, refinery. For a number of years Maker taught part-time at the University of California (Berkeley) Mechanical Engineering department, and after his retirement from Standard, accepted the Fullbright professorship.

A SPECIAL REPORT SPECIFYING EQUIPMENT

How to Specify Tanks

Keep in mind the basic rule that the purpose of a specification is to tell the bidder what you want

Kenneth L. Lange
Chicago Bridge and Iron Co.
Houston

WHAT DO the bidders need to know? What standards should my inspectors apply? Should I call for a corrosion allowance? How much X-ray? Why all of these fancy material specifications?

These are only some of the many questions encountered by the purchaser of large steel storage tanks of the types commonly employed to store petroleum and chemical stocks at atmospheric pressure. Just as is the case with other major engineering structures, a good specification, properly enforced, is one, but only one, of the ingredients of a job well done. The emphasis within the specification may vary, though, depending upon the desires and attitude of the purchaser and his buying policies.

Certainly it is basic that the specification should inform the bidders on what is wanted. When well written for this purpose it may serve equally well as a guide to the owner's inspectors for their use during the construction period. Since it will become a part of any contract or agreement between the purchaser and contractor it should be sufficiently detailed so that it can serve as a basis for the settlement of any misunderstandings that may arise between the owner and builder.

If the purchaser's buying policies are such that consideration may be given to quality features of the offering of the bidders, then perhaps the specification can be less detailed and

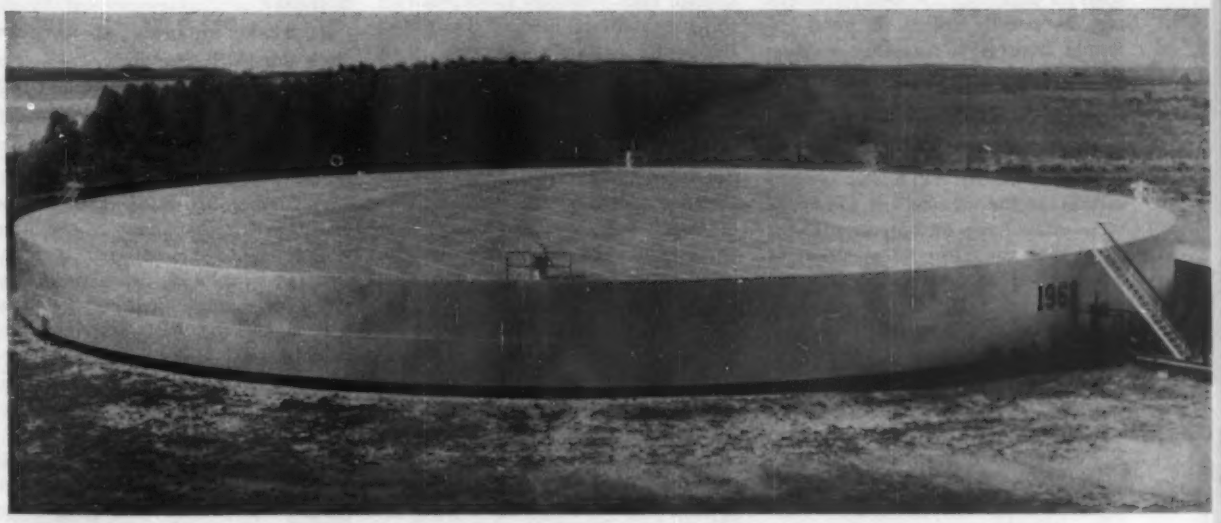

FIGURE 1—Tanks with low shell heights like this 14 by 200-foot, 78,000-barrel tank, cut foundation costs in marshy areas.

demanding. Where competition is to be reduced to mere consideration of low price only, then a specification in greater detail, if enforced, may raise the standards of some of the bidders. Even so, it will not supplant careful weighing of the advantages offered by each of the bidders.

Of course there is always present the spectre that by asking too much, costs may be unnecessarily increased. While this is generally recognized, an equally important, but less frequently considered premise is that by asking too little, full value will not be received. Similarly, failure to be explicit as to details and requirements desired may force the bidders to include a high contingency item in the price quoted for the work.

Within the framework of these comments we can consider those features of specifications for the purchase of tankage that are likely to result in a better job and greater value received.

An age-old, but often violated, maxim in the preparation of specifications is that results only should be named and not the methods of obtaining them. The purchaser might well reflect here upon the fact that the courts have on numerous occasions held that where a specification covers methods, the contractor ceases to be an independent contractor and is merely acting for the owner. Then too, the search for new and better ways of attaining the desired results can be readily stifled. A good example here is a complete welding procedure as a part of the owner's specification. While there may be good reason for interchange of ideas between fabricators and users of storage tanks as to the advantages of certain techniques which either of them may have authored, it seems clear that the ultimate selection of the method to produce the desired and specified result should rest with the contractor. He cannot otherwise be expected to guarantee it.

Delivery. Oftentimes a specification for purchase will ask that the bidder "quote your best price and delivery." While these two criteria may both be of interest to the purchaser, so far as any one bidder is concerned they may be incompatible. Improvements in delivery and completion time can frequently be accomplished through such costly devices as securing materials from premium sources, use of overtime in both the shop and field, and possibly multishift operations. The purchaser might well consider stating a desired date for completion of the facility yet leaving the bidders free to name other completion dates and corresponding prices if they so desire.

Storage Tanks." This specification is the result of joint efforts of both users and manufacturers of storage tanks. There can be little criticism of tankage constructed following the requirements of this specification. It is important to recognize, however, that it is a set of minimum standards so written in order that it might be applicable to a wide range of needs. Careful engineering of a given project will, in general, disclose those areas where some addenda to this

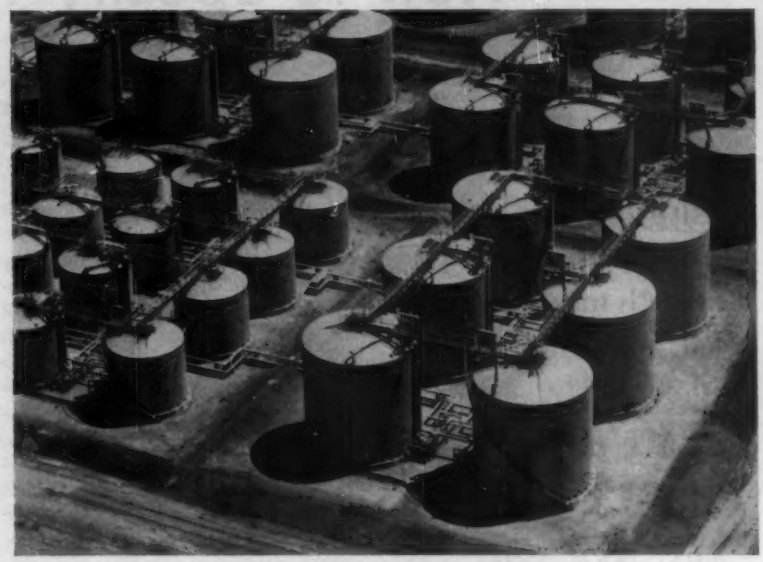

FIGURE 2—Batteries of small capacity tanks with self-supporting roofs use common walkways.

The construction of a field erected storage tank generally takes place on property under control of the owner, frequently within an existing plant facility. If the owner will be in a position to furnish utilities such as electric power, perhaps compressed air, and water, the specifications should so state in order that proper allowance can be made for this in the development of the estimate. A strong case can be made for the usual requirement that water for testing the completed tank be furnished, pumped, and disposed of by the owner. This utility, after all, is within his control.

API Specifications. In the purchase and construction of large storage tanks probably the most frequently applied standard is API Specification 12-C covering "Welded Oil

standard specification might well be applied.

It is also important to recognize that the API Standard 12-C is a suggested specification only and that it does not usually have the force of law as do the pressure vessel codes and other similar documents.

A further point that should be considered is that many of the large storage tank structures are constructed employing proprietary devices, for example floating roofs; and here again the API Standards are both general and broad and sometimes in need of further definite requirements.

Tank Sizes. While API 12-C lists a number of typical sizes of storage tanks these can by no stretch of the imagination be regarded as universal

standards. Common usage of certain proportions for certain capacities of tanks has resulted in a type of unofficial standardization within the industry. Examples here would be the common 55,000-barrel tank, 100 feet in diameter with a 40 foot shell height. These proportions have been accepted and employed widely not only by fabricators but also by users. On the other hand, certain specific sizes of tanks have been adopted by a particular user or fabricator and employed by him to the extent that he will regard it as a standard size even though others may not do so.

The question is frequently asked, "What is the most economical height of tank for me to build?" This question can seldom be answered by the tank builder since the controlling cost elements very likely are beyond his control. So far as the tank itself is concerned, the difference in cost between a tank 40 feet and 48 feet high may be negligible, assuming that their capacities are comparable. This is especially true of tanks with fixed roofs. For tankage with floating roofs, a higher tank will generally result in a lesser total cost for the structure but, here again, the difference is so slight that the selection will finally be based on the cost of elements other than the tank itself. Obviously, a higher tank may sometimes be impracticable because of limited bearing value of the soil at the site, or it may involve more extensive foundation work, perhaps even piling. Even if this is the case, there may still be economic justification for the higher tank with a lesser diameter if high real estate costs are involved, and better land usage may be realized.

The use of floating roof tanks with shell heights as great as 56 feet is no longer uncommon. Tanks with extremely low shell heights of the order of 16 feet to 20 feet have also been built in certain marshy areas (Figure 1). While the cost of the tank itself in this case is high the saving in foundation cost provides the economic justification.

Materials. As recognized in the API Specifications, the great majority of plate material used in storage tanks meets ASTM Standard A-283, Grade C. To a lesser extent materials meeting ASTM A-283, Grade D, and A-7 are also employed. These last mentioned materials are somewhat less ductile, and it is significant to note that API 12-C restricts their use to plates less than ¾-inch thick. While the API Specification also makes mention of certain other permissible grades of material, it does not make any recognition of the varying ultimate strengths of these materials.

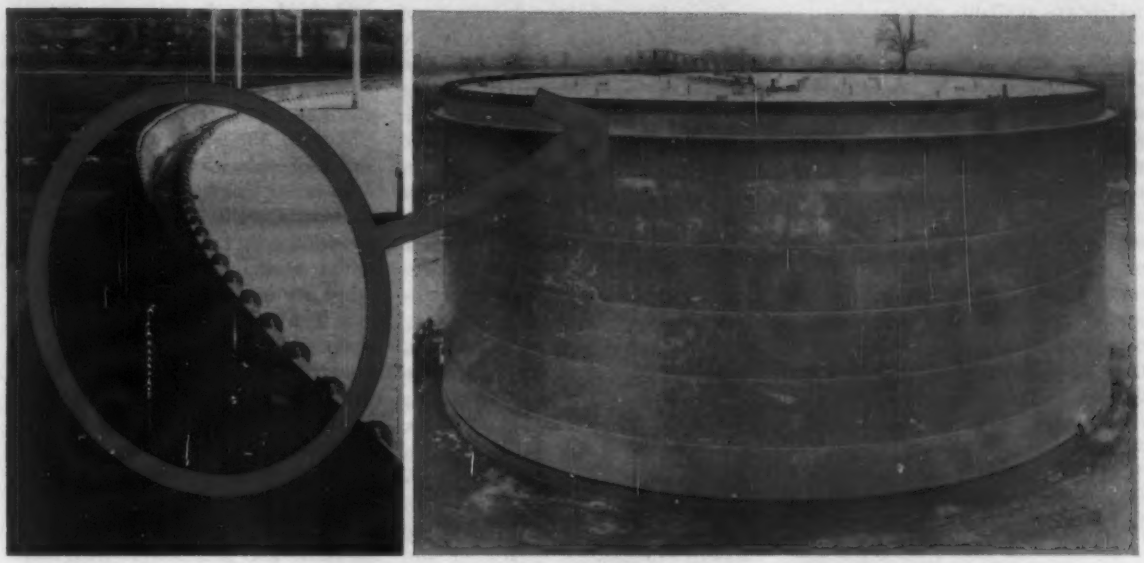

FIGURE 3—Floating roof tank with shoes exposed allows full volume use of tank to top of the shell.

In writing a specification then, the use of the expression, "a Standard API Storage Tank, 67,000-barrels capacity," needs some further amplification. Preferably both the desired diameter and height should be stated.

In selecting the capacities there may appear to be a need for unusual sizes. The facts are that such tanks, with diameters and heights not ordinarily encountered, can be built at unit storage costs not differing appreciably from those for tanks of more usual dimensions. At the same time the purchaser would be well advised to consider that the few barrels difference involved in going to the nearest size tank of more usual proportions may represent very inexpensive storage to him, and may result in a tank being more readily available for delivery from stock.

Much has been written in the technical literature in recent years about the brittle fracture of steel under certain conditions. A part of the concern here is for the use of these materials in large storage containers. In spite of the long and successful history in the use of A-283, Grade C plate and the comparable materials which were its forerunner, there appears to be good reason to consider the use of materials produced to more stringent specifications for some applications. Welded tanks are being built today in sizes that only a few years ago would have been considered impracticable. Not many years ago an 80,000-barrel

tank was considered a big tank, yet the thickness of the bottom shell course was less than half the 1½ inch shell thickness now permitted in the API specifications. The more commonly used tank steels evidence both a loss of notch toughness and inconsistency of impact value in heavier thickness ranges.

Notch Toughness. Attention has been focused on the problem of notch toughness by a few dramatic failures, and the users of tanks should at least be aware that materials are available at a modest cost differential which will minimize this problem. The most promising of these materials is that produced to ASTM A-131 in various grades, each applicable to a specific thickness range. The extra cost for employing steel to this specification in a tank shell is, of course, a function both of tonnage and the thickness of material involved. However, on tanks as small as 55,000-barrels the use of A-131 for the shell will result in an additional cost of less than ½ cent per barrel. For tanks 80,000 barrels through 150,000 barrels, the additional cost will be from ¾ cents to slightly over 1 cent per barrel and even on the largest tanks that can be built under present API 12-C requirements, the additional cost will be less than 3 cents per barrel. These are indeed modest increments of cost when it is considered that the total investment in tankage for any of the above sizes will probably be from $1.50 to $2 per barrel for the complete installation.

While API 12-C has been silent on this matter, except to recognize the existence of these higher quality steels and to permit their use, there have been a variety of rules developed both by fabricators and tank users defining the limits of application of special notch-tough materials. These rules in general involve two criteria; thickness limits, and either geographic location or the anticipated temperature range to be encountered. The consensus indicates that the most concern is felt when the steel thickness is greater than perhaps ⅝ inch to ⅞ inch as a lower limit and would consider its use in all but the very warmest areas. Fortunately, this material is produced by most of the major mills and, accordingly, its procurement is not great problem. As its use becomes more widespread, undoubtedly many fabricators will carry it in their stock though this is not as yet common practice.

For some special service applications such as acid or caustic storage, it is not uncommon to call for a better quality of steel, perhaps fully kilned material, which would offer the advantage of more uniform composition. Since the great majority of acid and caustic storage tanks are not large and the tonnage involved not great, the additional cost of these higher quality steels which may be in the range of $15 to $20 per ton will not pose an exhorbitant additional cost. Specifications should also state both type and degree of concentration of acid or caustic to be stored, as this may influence electrode selection and welding procedure to be employed.

Electrodes. Paralleling the advances in the art of welding, there have in recent years been many new welding electrodes. It is neither necessary nor desirable that the user in his specifications designate any particular electrodes. Rather he should see to it that the provisions regarding random examination of welding and procedure qualifications, as established in the API Standards, are rigorously applied. This will be far more instrumental in obtaining the desired result.

Design Details. While the usual tank bottom is of lap-welded construction, for some types of service and, particularly where a tank lining may be employed, a butt-welded bottom may be desired. The API Standards outline a permissable type of construction utilizing backing-up strips with all welding of the bottom to be accomplished from one side. There is, however, the ever present hazard with this detail of a notch effect from incomplete welding of the joints in the backing-up bar itself. Much to be preferred is construction involving double welding of the bottom from both sides. In smaller diameters this can be accomplished readily and inexpensively by turning the bottom over, after welding from one side has been completed and in larger diameters, by erecting the tub on horses and lowering it to the grade after completion of the bottom welding.

Allowable Stress. Several provisions of the API Standards covering design of shells are worthy of comment. The allowable working stress of 21,000 psi is established in this specification. When reduced by the permissible 85 percent joint efficiency and further reduced by consideration of the fact that many of the petroleum stocks stored have a specific gravity substantially less than unity, the actual working stress in the plates in the shell will be of the order of only 15,000 or 16,000 psi. Viewed in this light there is reason to question the provision of this specification which permits application of the 21,000 psi basic stress when storing liquids with a specific gravity substantially greater than unity. It would appear here that a base stress of approximately 18,000 psi would more closely check the usual experience and should be used as a criteria in designing shells for storing heavier liquids.

Shell Thickness. For tanks smaller than 50 feet in diameter, these specifications also permit 3/16-inch minimum thickness for shell plates. The use of somewhat thicker materials, say ¼-inch plate, results in only a modest increase in the cost of the completed structure and may add materially to the useful life of it. As for example, on a 10,000-barrel tank 42 feet, 6 inches in diameter with a 40-foot shell height and built with five equal courses 8 feet in width, the additional cost of the shell material for ¼-inch minimum plate as against 3/16-inch plate would be only approximately $450. As a matter of usual practice, however, the 3/16-inch minimum shell would generally be made in a greater number of rings with a consequent increase in the number of pieces to be handled, footage of seam to be welded, all reducing the saving to be realized from using the thinner material. It would appear here then that the additional cost of some-

thing less than 4½ cents per barrel on a structure costing from $1.50 to $2 per barrel may result in a considerable extension to its useful life.

Welding. The type of welding to be employed on horizontal or girth joints has also been the subject of much discussion and considerable revision within the API Specifications themselves. With the advent of automatic welding equipment for those particular joints, it has been possible to provide 100 percent penetration of the weld deposit without incurring any substantial increase in cost. This type of joint can of course be examined by radiographic methods; whereas such investigation of partial penetration joints is unreliable. Too, the almost simultaneous deposit of the weld metal on both the inside and outside of the joints has served to minimize the banding effect on the shell from these weld deposits. With shell plates approaching 1½ inches in thickness, however, it is possible with automatic equipment to make a partial penetration joint, and it appears desirable to again consider this detail rather than to deposit the tremendous quantities of weld metal required for complete penetration. Even on large tanks, the purchaser cannot assume that he will receive full penetration and if this is desired the specification should call for it.

Wind Girders. The service record of wind girders complying with the requirements of API-12C is both long and good. There is no reason to suggest change in these rules, even for locations involving higher than normal wind velocities, except possibly for tanks of either considerably greater size or radically different proportions than have been constructed to date.

Many users apparently are not aware that API Specifications will permit installation of the wind girder less than 2 feet from the top of the tank shell, and in that case to eliminate any top curb angle on the shell. While the cost of the wind girder itself will not be changed appreciably by its location, the elimination of the top or curbing angle may represent a substantial saving. If, on the other hand, it is the intention to have the wind girder located some 3 feet or more below the top of the tank and to use it as an auxiliary or emergency walkway, then this saving must be foregone. It is important, however, that the purchaser state his intentions in this regard.

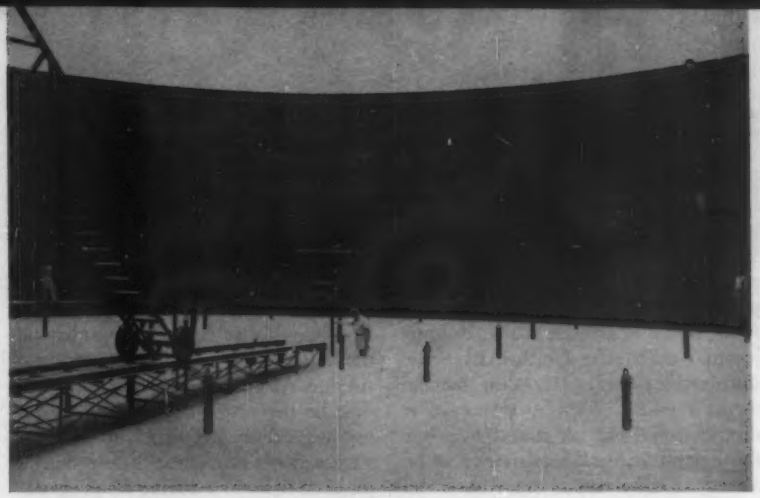

FIGURE 4—Strain gage tests on this 200-foot diameter, floating roof tank being made with full water load on the center deck.

Self-Supporting Roofs. On many smaller tanks, say 20 feet or 25 feet in diameter, it is possible to provide self-supporting roof construction at no additional cost over the conventional framed cone roof. This self-supporting roof may be in the form of a dome or spherical segment, or as a self-supporting cone roof. In some services the elimination of inside framing will be considered an advantage. For small tanks of this type installed in batteries, some thought should be given to the matter of access if self-supporting roofs are employed (Figure 2). These roofs generally have a steeper pitch, at least near their outer periphery, and do not therefore lend themselves well to use as a walkway or platform. Separate catwalk structures may be required. Because of the steeper pitch of these roofs at their point of attachment to the shell a stronger joint results. This may be disadvantageous in event of an explosion within the tank.

Usual welding details on the roof plates will involve lap joints welded from the top side only. This detail may be entirely unsatisfactory if any special interior lining is being contemplated and, if so, this should be clearly brought to the attention of the bidders.

Floating Roofs. While certain minimum requirements regarding floating roofs are established in Appendix C of API 12-C, it must be remembered that these are proprietary devices, and consideration of proposals cannot be made on the basis of price only (Figure 3). Attention should be given to the shape of the float, the extent to which it blankets the stored product, its characteristics for entrapping vapors that may form, its drainage characteristics, stability, and maintenance characteristics (Figure 4). Design of the seal for closing the space between the float and the shell should consider not only its fit and effectiveness to provide a vapor barrier at this point, but also whether it will accommodate expected changes in the shape of the tank due to settlement or other causes, how well it will function in the event of an explosive fire, and surely the type, grade, and thickness of materials used in the seal both for metallic and non-metallic parts. Some loss of capacity of the tank may occur if the seal details will not permit complete filling of the shell (Figure 3). It would be unfortunate to pay for an 80,000-barrel tank only to discover it cannot hold more than 75,000 barrels of product. It is desirable to state the service for which the floating roof is intended as this may have some influence on the fabricators offering, particularly as regards selection of some of the materials involved. Again, because of difference in function of various floating roofs, it is not wise for the purchaser to specify venting equipment desired on the roof in detail. Rather it would be preferable to indicate the maximum liquid filling and withdrawal rates and leave the selection of the necessary vents to accommodate these conditions in the hands of the fabricator.

Corrosion Allowance. When a corrosion allowance is desired on a storage tank or a portion of it, it is

important that this be covered in the specifications. Thickness of certain parts, particularly roof plates, bottom plates, and sometimes shell plates, is not controlled by stress produced by the weight of the contents, but is rather an arbitrary minimum established either by some standard specification or by the owner's own rules. In this case it should definitely be stated whether the corrosion allowance is to be added to such members where the thickness is controlled by arbitrary minimum rather than by stress.

Accessories. A clear statement as to the accessory items desired on a tank is also necessary. Many users have developed details of their own for specific accessory items; and if it is the intention that these details be followed, they should of course accompany the inquiry and specifications. So far as possible, however, the actual detail of the accessory item should again be left to the fabricator so that his usual practices may be followed with a consequent improvement in cost. The API Standards establish certain general requirements regarding arrangement and loading for platforms, walkways, and stairways. Here again, the purchaser need only to specify as to the arrangement desired and indicate whether grating or some other type of flooring material will be considered acceptable.

Inspection. If the purchaser wishes to place his reliance for quality of the completed work in a standard such as API 12-C, it is not necessary that he say much beyond this in detail regarding inspection and the various tests and scrutinies to be applied to the work during its progress. Here the lack, if one exists, is not in the specifications available but rather in their application. It is true of course that the API Specifications place the responsibility on the manufacturer to police his own workmanship. This philosophy, however, does not deny to the purchaser the prerogative of ascertaining for himself that all provisions are being properly followed.

Especially in the control of welding some further comment may be in order. Welding in tankage constructed under the API Specifications is still inspected both by trepanned samples and by radiographic techniques. While we cannot condemn the trepanned specimen inspection technique because of its long and successful application, we must recognize the advantage of non-destructive inspection methods. Although the equipment for radiographic spot examination can be made available on a job of any size it may be distinctly uneconomical on a small single tank job and, therefore, unless radiographic spot examination is specifically called for by the purchaser it may not be the technique applied in every case.

Right along with the testing method, whether it be by trepanned plugs or by spot radiograph, it is essential that a standard for judging the specimens be clearly established. If API 12-C is being followed, this matter has been well defined. When it is the intention to apply some standard of acceptability other than that described in this specification, this should be definitely stated for the benefit of those bidding.

The API Standards are explicit as to the number of random examinations that shall be made and, here again, it is the prerogative of the owner to satisfy himself as to the adequacy of the inspections made by the manufacturer and the suitability of his techniques.

It should be recognized that with either inspection technique, random examination does not have as its goal the seeking out and correction of every flaw in the weld as deposited in the structure. Rather it is a policing action intended only to produce a reasonable standard of workmanship and to see that this is followed. Many have considered, and some have actually specified, 100 percent radiographing of vertical seams in storage tank shells. This relatively costly requirement may not produce an improvement in the structure commensurate with the added expenditure. It overlooks the possibility that any transverse cracks in the girth joints will lie across the principal line of stress of the tank shell and may be far more dangerous than minor flaws in the vertical joints. The longitudinal shrinkage of the tank shell along the girth joints is considerable, and tends to aggravate the situation just described. Of course, complete radiographing both girth joints and vertical joints would involve an even greater expenditure —considerably more than the cost of merely taking the pictures. Assuming that a decision has been made to go beyond the dictates of API 12-C in the quality of the completed tank. The purchaser might well consider the use of a notch-tough material as discussed earlier, rather than to make a big investment in X-ray examination. While the use of this material will not necessarily eliminate flaws in the weld deposit, it will surely minimize their consequences.

Contrary to popular belief, a competent contractor welcomes thorough inspection practices by the owner. Both are interested in the same result.

These are only a few of the items worthy of thought in preparing specifications for the purchase of tankage. No such specification can be expected to cover all cases and applications. Good practice is not a static thing, and the alert specification writer must be constantly aware of new methods and materials and be able to apply them to the benefit of the final result. # #

About the Author

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How to Specify Pumps

A standard specification form and vendor's data sheet eliminates errors, helps in bid evaluation and keeps your time at a minimum

F. N. Hull and E. R. Lane
Phillips Petroleum Co.
Bartlesville, Okla.

PUMPS ARE one of the most important parts of a processing plant. The reason for their importance is that they move nearly all liquid mediums through the process equipment. To insure continued profit to the owner, pumps must be specified that will give, as nearly as possible, continuous operation. This can be accomplished best by careful consideration of the variables which affect the operation of the equipment: corrosive materials present in the fluids being pumped, service requirements, type of pump best suited for the job, kind of packing or seals, capacity and hydraulic requirements.

Pumps used in process plants are of two basic classes: (1) centrifugal and (2) positive displacement type, such as rotary, reciprocating or diaphragm. Turbine type pumps have characteristics which are similar to both the centrifugal and positive displacement pumps and are, therefore, not considered a separate basic class.

Specification Forms. Pump manufacturers should be supplied complete data concerning the pump required. The use of standard specification forms to give manufacturers these data is recommended, and will insure the purchaser that the manufacturer receives the necessary basic data to make the proper selection. (Note: Standard forms similar to those covered in this article can be found in API Standard 610).

Figure 1 shows a data sheet for centrifugal pumps. This form is a

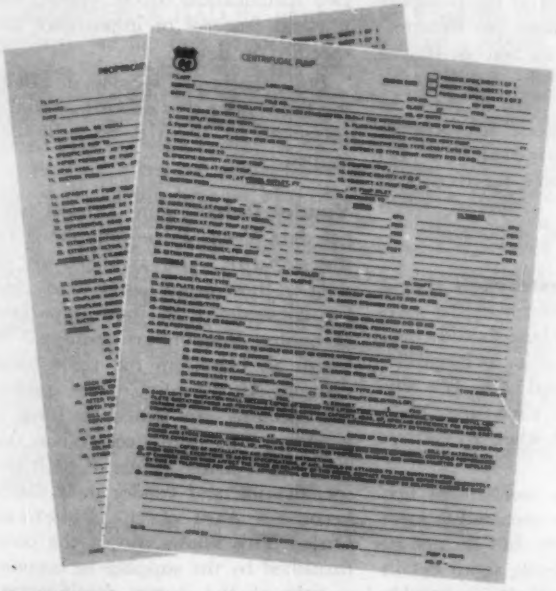

FIGURE 1—Specification sheets give the vendor details of construction as well as data about the fluid being pumped.

FIGURE 2—Vendor data sheets cover the details of his quotation in convenient tabular form.

convenient means of furnishing a vendor the details of construction as well as pertinent data about the fluid to be pumped. The sheet is divided into the following subdivisions which will give a complete specification for most pumping applications:

- Type
- Characteristics of fluid to be pumped
- Capacity and head requirements
- Materials of construction
- Driver data
- Data required with quote
- Other information

Only those spaces are completed which are necessary to describe the type of pump that is required for the job. This allows the supplier to make alternate offers for consideration.

Note that pumps for special fluids, such as HF acid or aluminum chloride slurries, require much more elaborate specifications.

Unacceptable features for a particular application, such as integral motor drives, or support head type mounts should be shown on the specification form. Performance tests should be specified, if required, since tests usually are not performed for each individual production line pump.

Fluid Pumped. Complete information should be given regarding the fluid to be pumped. This information should include products which might cause corrosion, pumping temperature, viscosity, specific gravity at 60° F and at the pumping temperature, vapor pressure at 60° F and at the pumping temperature, and net positive suction head available at both the vessel outlet and pump inlet. Also include a sketch showing the piping arrangement to help the manufacturer calculate the static heads required.

The capacity and head at initial and ultimate conditions should be specified. Normally the capacity should be calculated at the pumping temperature in gallons per minute.

Ordinarily the suction pressure and discharge pressure as well as the head is specified. This is done to offer a double check for possible errors in head calculations. Efficiency and operating speeds should be specified and explained when they are of special importance.

Materials of construction should be specified to conform to the service requirements. These should cover all principle parts, such as impellers, wear rings, shaft, and case. The type of base plate or mounting plate should be specified when special requirements dictate.

There are many mechanical features which may be specified to meet special requirements; but do not go overboard in specifying small details as these may eliminate acceptable offerings.

Driver. The type of drive should be specified and should include the power characteristics or steam conditions available, depending on the type of driver. The driver should be large enough to meet design conditions plus a reasonable load factor or the maximum horsepower for end of curve conditions. Also include the make and type of coupling required. Spacer type couplings may be desirable with the larger horizontal split case pumps, since these couplings make it easier to replace mechanical seals or bearings.

Vendor Literature. Sufficient data should be requested from the vendor to fully analyze their offering. This should include complete descriptive literature, outline drawings for both the pump and drive if furnished by vendor, performance curves for minimum design, maximum size impellers, net positive suction head required and installation instructions. When similar pumps are being specified, a parts interchangeability list will be helpful in reducing spare parts.

Reciprocating Pumps. Figure 1 also shows the data sheet used in specifying a reciprocating pump. Notice the similarity between the two specification sheets. Again, the physical features of importance are specified in detail.

Both sheets are specific in advising the vendor that exceptions to the specifications should be fully described.

Vendor Data. Figure 2 shows typical data sheets to be completed by the vendor. The arrangement of data on these sheets has been selected for convenience in the comparison of quotes. Vendors are requested to fill in all blanks in the right hand column. After receipt of the quotes, the columns are joined to form a master comparison sheet. When the selection is made, prints of both the specification and vendor data sheets become a part of the Purchase Order. This allows use of the data furnished by the supplier to become a part of the pump specification. ##

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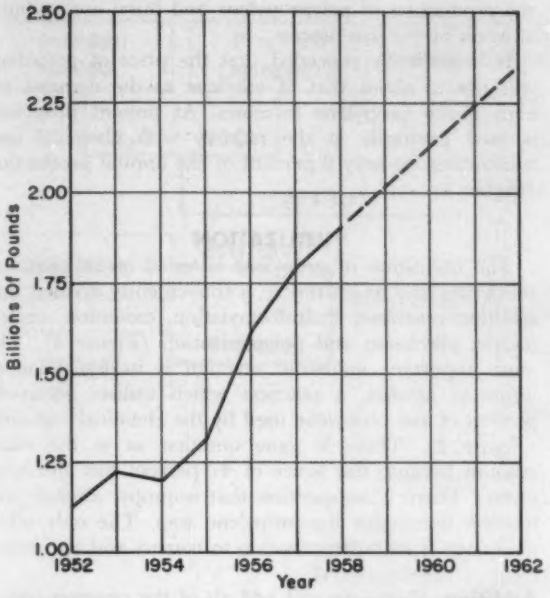
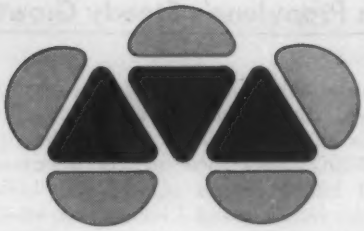


FIGURE 1—Here's how propylene production for chemical use has grown in the last few years.



The magic of double bonds and methyl groups are reflected in the growth, utilization and future of propylene

Watch Propylene's Steady Growth

Lewis F. Hatch
The University of Texas, Austin

PROPYLENE HAD the distinction of being the raw material for the first petrochemical—isopropyl alcohol, and for the next thirty years propylene rested on its laurels while ethylene took over the leadership. Ethylene will maintain this dominance for a long time to come because of its wide variety of useful derivatives.

Within the last ten years, however, propylene has diversified and this broader base of utilization is reflected in the increasing use of propylene by the chemical industry (Figure 1). Petrochemical propylene has doubled production within these ten years and 2.7 billion pounds is estimated for 1965.[1] Much of this new propylene is going into detergents and oxo alcohols by way of tri- and tetrapropylene. The production of isopropyl alcohol is still the single largest use and accounts for approximately 55 percent of propylene's chemical utilization (Figure 2).[2]

Propylene differs from ethylene by only a methyl group.

$CH_2=CH_2$ Ethylene $\qquad$ $CH_3CH=CH_2$ Propylene

But what a difference a methyl makes! It loosens the double bond so that addition reactions go more readily and, if the addendum is unsymmetrical, it will determine the position taken by the entering groups. For example, the hydration of propylene yields isopropyl alcohol instead of *n*-propyl alcohol.

$$CH_3CH=CH_2 + H_2O \rightarrow CH_3CHOHCH_3$$

The methyl group also provides a point of attack for substitution reactions (allyl chloride) and oxidation (acrolein).

$$CH_2=CHCH_3 + Cl_2 \rightarrow CH_2=CHCH_2Cl + HCl$$

$$CH_2=CHCH_3 + O_2 \rightarrow CH_2=CHC(=O)-H + H_2O$$

With all of these advantages why has propylene remained a country cousin to ethylene? Not all of these advantages are as advantageous as they might seem. The directing influence of the methyl group is not always desirable for it makes it impossible to produce many primary propyl derivatives. The newer uses of propylene either by-pass this feature or the chemist has learned how to live with it. All of the derivatives of ethylene are primary.

PRODUCTION

Propylene has been described as holding a unique position as a chemical raw material—it is produced

economically only as a by-product or a co-product.[3] It is obtained commercially as a by-product of refinery operations and a co-product from ethylene plants. The total potential from these sources is estimated to be about 21 billion pounds of which 20 billion pounds comes from refineries and 1 billion from ethylene plants. The growing demand for ethylene will increase the supply of propylene for they are as inseparable as rock and roll. Much of this ethylene will come from the cracking of LPG which will account for about half of the ethylene production by 1960.[4]

Refinery propylene is a propane-propylene mixture containing 40 to 60 percent propylene and is obtained as a by-product of cracking operations. This material is of sufficient purity for the production of isopropyl alcohol, tripropylene, tetrapropylene and cumene and for refinery uses. Propane pyrolysis to produce ethylene also gives a propane-propylene mixture of approximately the same composition. The pyrolysis of butane and higher hydrocarbons yields a propylene cut containing at least 90 percent propylene.

The newer uses of propylene demand a propylene of high purity. This purity can be obtained but at a price. Propylene may be purified by distillation at a cost of about 2.5 cents/gal. if the starting material contains between 40 and 60 percent propylene and at a cost of about 1.5 cents if 90 percent propylene is used.[3] The product is 99 percent propylene. The high purity propylene is used for the reactions involving the methyl group (substitutive chlorination and oxidation) and for the production of polypropylene and butyl and isobutyl alcohols by the oxo process.

It is generally conceded that the price of propylene will rise to about that of ethylene as the demand for high purity propylene increases. At present propylene is used primarily in the refinery with chemical uses accounting for only 9 percent of the annual production (Figure 3).

UTILIZATION

The utilization of propylene is based on its chemical properties and its chemistry is conveniently divided into addition reactions, hydroformylation, oxidation, chlorination, alkylation and polymerization (Figure 4). The most important industrial reaction is its hydration to isopropyl alcohol, a reaction which utilizes about 55 percent of the propylene used by the chemical industry[2] (Figure 2). There is some question as to the exact amount because the figure of 47 percent has also been given.[3] There is no question that isopropyl alcohol production dominates the propylene uses. The only other major use is its polymerization to trimers and tetramers.

Addition. Propylene will add all of the reagents which characteristically add to a carbon-carbon double bond. The only industrially important derivatives are the addition products of sulfuric acid (to make isopropyl alcohol), hypochlorous acid (to make propylene oxide and glycol), other propylene molecules, butylenes, benzene and carbon monoxide and hydrogen. The reaction of propylene with other olefins and benzene will be discussed separately because the reactions are not generally considered as typical addition reactions. The ad-

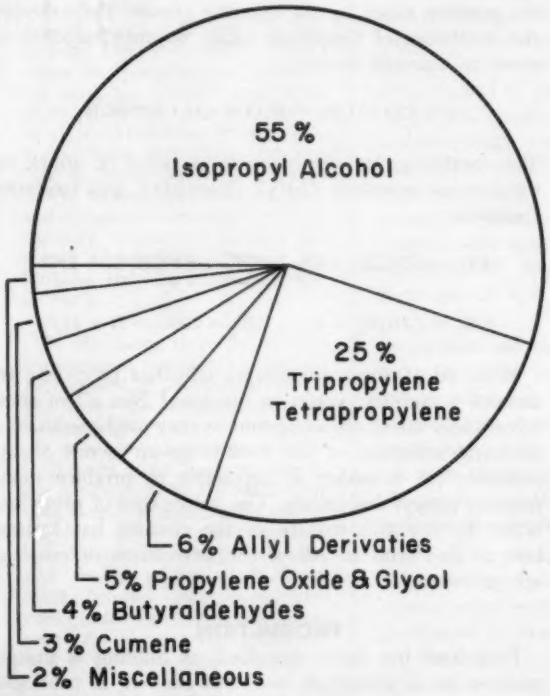


FIGURE 2—Isopropyl alcohol still accounts (left) for more than half of the 1958 chemical use of propylene.[2]

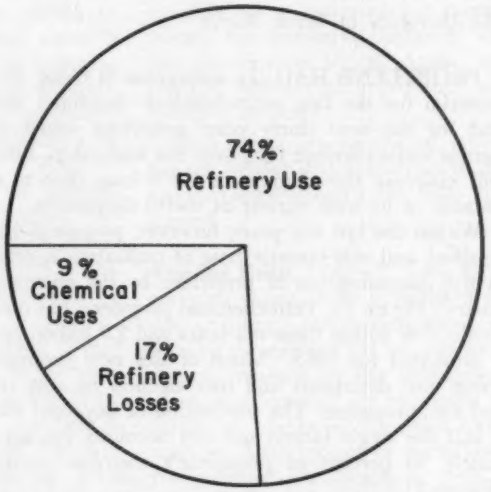


FIGURE 3—Present propylene use is dominated by refiners for fuel production.[2]

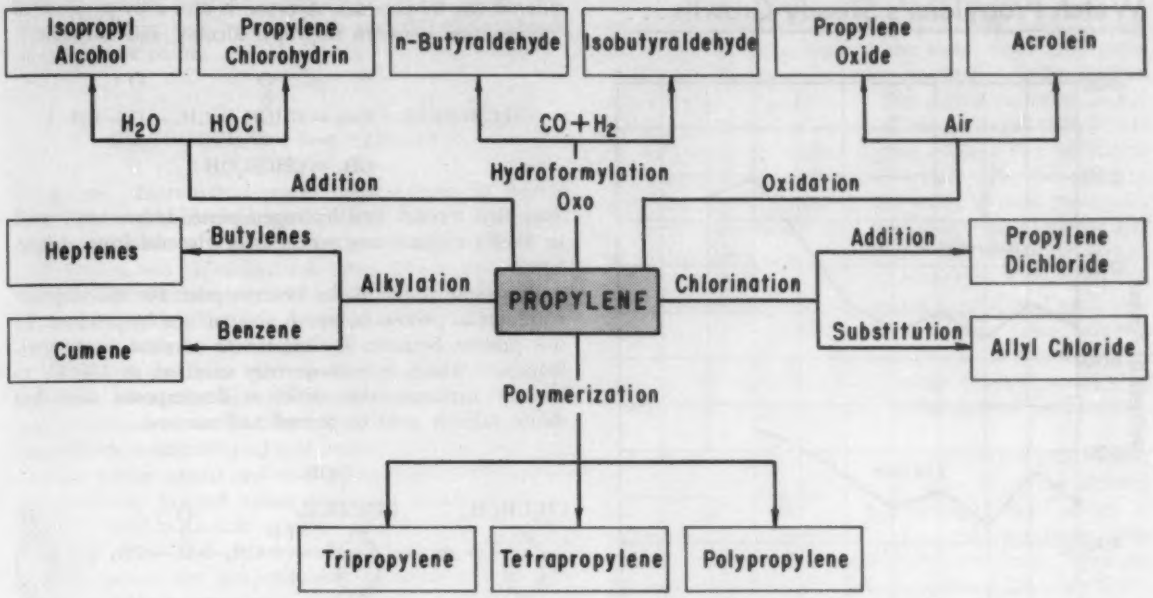


FIGURE 4—These six reaction routes make propylene a valuable raw material.

dition of carbon monoxide and hydrogen (hydroformylation, oxo reaction) is sufficiently different and important to warrant separate treatment.

Isopropyl Alcohol. Isopropyl alcohol (2-propanol, isopropanol) is produced commercially by a two-step, liquid phase process involving sulfation of the propylene with sulfuric acid followed by hydrolysis of the isopropyl hydrogen sulfate.

Sulfation

$$CH_2=CHCH_3 + H_2SO_4 \rightarrow (CH_3)_2CH\text{-}O\text{-}SO_3H$$

Hydrolysis

$$(CH_3)_2CH\text{-}O\text{-}SO_3H + H_2O \rightarrow CH_3CHOHCH_3 + H_2SO_4$$

The feed stock usually contains about 50 percent propylene with the remainder being propane. Ethylene may be present for it is less reactive than propylene but other olefins and diolefins are more reactive than propylene and must be absent. The feed mixture is absorbed by 75 to 85 percent sulfuric acid, usually 85 percent, at 24 to 27°C. with a hydrocarbon to acid ratio of 1.0 to 1.5. The pressure is somewhat above atmospheric.

The main side reaction is the formation of diisopropyl sulfate which leads to diisopropyl ether production when the

$$(CH_3)_2CH\text{-}O\text{-}SO_3H + CH_2=CHCH_3 \rightarrow (CH_3)_2CH\text{-}O\text{-}SO_2\text{-}O\text{-}CH(CH_3)_2$$

absorption mixture is diluted to effect hydration and alcohol formation.

$$(CH_3)_2CH\text{-}O\text{-}SO_2\text{-}O\text{-}CH(CH_3)_2 + CH_3CHOHCH_3 \rightarrow (CH_3)_2CH\text{-}O\text{-}SO_3H + (CH_3)_2\text{-}O\text{-}CH(CH_3)_2$$

The absorption mixture is diluted to an acid concentration of 30 to 40 percent by the addition of water or steam at 80° to 100°C. The hydrogen sulfate ester is hydrolyzed and the liberated isopropyl alcohol distills as formed. The isopropyl alcohol is obtained as its 91 percent water azeotrope. Diisopropyl ether is the by-product (*ca.* 5 percent) and the sulfuric acid is concentrated for reuse. Anhydrous isopropyl alcohol may be produced by azeotropic distillation with diisopropyl ether or similar entraining agent. Both concentrations are commercial.

The direct vapor phase catalytic hydration of propylene has been studied extensively and at least one plant in England uses this type of process. Promoted tungsten oxide is the preferred catalyst with a temperature range of 260° to 320°C. at 80 to 200 atmospheres pressure. The system is saturated with steam. The conversion is about 9 percent per pass and the overall yield is 94 percent. The by-products are diisopropyl ether, polymer and *n*-propyl alcohol. One of the economic disadvantages of this process is the necessity of concen-

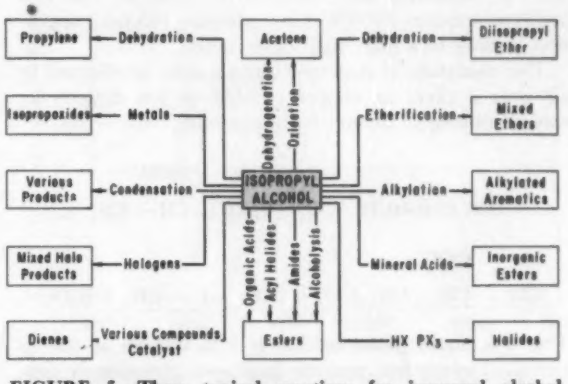


FIGURE 5—These typical reactions for isopropyl alcohol show the versatility of propylene.

Watch Propylene's Steady Growth . . .

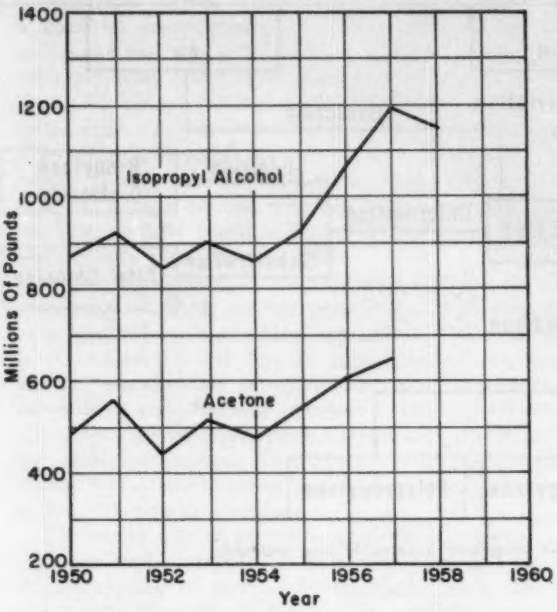


FIGURE 6—Since over 80 percent of the current acetone production comes from isopropyl alcohol, here's how the production of each is related.

trating the dilute (39 percent) isopropyl alcohol solution initially formed. The requirement of a high purity propylene feed is another disadvantage.

Isopropyl alcohol is a secondary alcohol and its reactions are typical of alcohols of this type (Figure 5).[20] The most important reaction is its dehydrogenation or oxidation to acetone.

Dehydrogenation:

$$CH_3CHOHCH_3 \rightarrow CH_3-\overset{\overset{O}{\|}}{C}-CH_3 + H_2$$

Oxidation:

$$CH_3CHOHCH_3 + O_2 \rightarrow CH_3-\overset{\overset{O}{\|}}{C}-CH_3 + H_2O$$

Dehydrogenation is the preferred process with copper, brass or supported zinc oxide as the catalyst. This is a high temperature (500°C.) low pressure (45 psi.) operation leading to a high yield of acetone.

The oxidation of isopropyl alcohol may be effected by air over a silver or copper catalyst or less directly by way of isopropyl alcohol hydroperoxide.

$$2CH_3CHOHCH_3 + O_2 \rightarrow 2CH_3-\underset{\underset{OOH}{|}}{CH}-CH_3$$

$$2CH_3-\underset{\underset{OOH}{|}}{CH}-CH_3 + O_2 \rightarrow 2CH_3-\overset{\overset{O}{\|}}{C}-CH_3 + H_2O_2$$

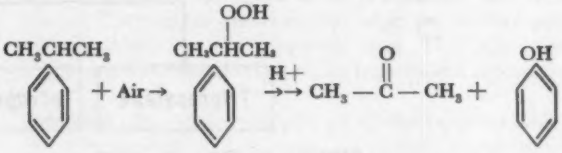
This is a liquid phase oxidation with oxygen at 100 to 105°C. Twenty-five percent hydrogen peroxide is produced in a 90 percent yield and the acetone is considered the by-product. Acetone is also a by-product of the reaction between isopropyl alcohol and acrolein.

$$CH_3CHOHCH_3 + CH_2=CHCH \rightarrow CH_3-\overset{\overset{O}{\|}}{C}-CH_3 +$$

$$CH_2=CHCH_2OH$$

The allyl alcohol and hydrogen peroxide are both used in Shell's elegant new synthesis of glycerol from propylene.[5]

Propylene is one of the raw materials for still another commercial process in which acetone is a by-product. In this process benzene is alkylated to cumene (isopropylbenzene) which is subsequently oxidized at 130°C. to cumene hydroperoxide which is decomposed with hot dilute sulfuric acid to phenol and acetone.



Over 80 percent of the current acetone production comes from isopropyl alcohol and this relationship between isopropyl alcohol and acetone production is illustrated by Figure 6. By-product acetone is making inroads into isopropyl alcohol acetone and even keener competition is expected in the future. At present acetone capacity is appreciably in excess of production.[6] About 33 percent of the acetone is used directly as a solvent and 31 percent is used in the synthesis of higher boiling solvents (methyl isobutyl ketone, methyl isobutyl carbinol, mesityl oxide, hexylene glycol, diacetone alcohol, and isophorone) and 16 percent is used to produce methyl methacrylate and bisphenol A.[7]

Propylene Chlorohydrin. Propylene chlorohydrin is produced by the reaction between hypochlorous acid and propylene. The hypochlorous acid is formed by dissolving chlorine in water.

$$Cl_2 + H_2O \rightleftharpoons HCl + HOCl$$

$$CH_3CH=CH_2 + HOCl \rightarrow \underset{90\%}{CH_3CHOHCH_2Cl} +$$

$$\underset{10\%}{CH_3CHClCH_2OH}$$

A temperature of about 50°C. is used and gaseous propylene is passed into the dilute aqueous hypochlorous acid solution in a tower reactor. Propylene reacts more rapidly with both hypochlorous acid and chlorine than ethylene does. The relative rates of addition of the acid and of chlorine are less favorable than with ethylene; thus, the formation of the dichloride is more of a problem. A mixture of ethylene and propylene may be chlorohydrinated but current practice is to chlorohydrinate them separately. The same equipment may be used for both olefins.

The addition of hypochlorous acid to propylene results in the formation of 90 percent 1-chloro-2-propanol

and 10 percent 2-chloro-1-propanol. This is not an economic disadvantage because both isomers are converted to propylene oxide.

$$CH_3CHOHCH_2Cl + \text{base} \rightarrow CH_3\underset{\diagdown O \diagup}{CH}CH_2$$

Propylene chlorohydrin reacts twenty times as rapidly as ethylene chlorohydrin and this difference in reactivity has been used to separate propylene oxide when the two olefins are chlorohydrinated as a mixture. Essentially all of the propylene chlorohydrin is converted to propylene oxide. There is no commercial production of propylene oxide by direct oxidation of propylene.

Propylene oxide is used as an intermediate for the synthesis of textile fiber lubricants, dyes, coating and pigment binders, antioxidants, emulsifiers, petroleum demulsifiers, lubricating oil and fuel oil additives, nonionic surface active agents and therapeutic agents. Because of its reactivity toward active hydrogen atoms propylene oxide is used as an acid accepter and stabilizer for vinyl chloride resins and chlorinated solvents. It has a high solvent power for nitrocellulose, cellulose acetate and vinyl chloride-acetate resins, and it is also a good solvent for hydrocarbons, gums, shellac and similar materials. It boils at 34°C.

The single most important use of propylene oxide is in the production of propylene glycol.

$$CH_3\underset{\diagdown O \diagup}{CH}CH_2 + H_2O \rightarrow CH_3CHOHCH_2OH$$

The hydration is carried out under pressure in a manner similar to that used for converting ethylene oxide to ethylene glycol. The production of propylene glycol in 1952 was 91 million pounds but dropped to 51 million pounds in 1954. The drop in propylene glycol production corresponded to an increase in the availability of ethylene glycol for antifreeze for which propylene glycol is a substitute when ethylene glycol is in short supply. It is still used as an antifreeze whenever the possibility of physiological action of the antifreeze solution is important.

The current increasing production corresponds to a steadily increasing use of propylene glycol in the manufacture of polyester resins, fatty acid esters and hydraulic fluids. It is also used in the production of pharmaceuticals, flavors, cosmetics, plasticizers and as a tobacco humectant. Its innocuous physiological properties make it suitable for general use by the food industry.

Hydroformylation—Oxo Reaction. An appreciable quantity of propylene is utilized either directly or indirectly by the producers of alcohols by the oxo process.[8,9] Direct utilization is by the hydroformylation of propylene to give a mixture of *n*-butyraldehyde and isobutyraldehyde.

$$CH_3CH=CH_2 + CO + H_2 \rightarrow CH_3CH_2CH_2\overset{O}{\overset{\|}{C}}-H + \underset{CH_3CH-\overset{O}{\overset{\|}{C}}-H}{\overset{CH_3}{|}}$$

This is a liquid phase reaction at about 150° to 180° C. and under a pressure of 3,000 psi. Cobalt is the catalyst and it may be introduced as the metal or as an organic cobalt salt. The actual catalyst is thought to be dicobalt octacarbonyl ($Co_2(CO)_8$). The aldehyde ratio is approximately 2 to 1 in favor of the *n*-butyraldehyde but the ratio may be varied within limits. The aldehydes are separated and utilized separately. The *n*-butyraldehyde may be hydrogenated to *n*-butyl alcohol (butanol), an alcohol which is firmly established as a solvent and an intermediate for plasticizers and resins. It is also used to synthesize a variety of other chemicals. Over 200 million pounds of *n*-butyl alcohol is produced each year with most of this production coming from non-oxo sources. This may be changed within the next year because of an announced expansion in oxo capacity by Texas Eastman which makes butyl alcohol by this process.

Isobutyraldehyde is hydrogenated to isobutyl alcohol which has many uses similar to those of *n*-butyl alcohol. Isobutyraldehyde is also used to produce a variety of higher molecular weight mono- and dihydroxy compounds through aldol condensation reactions. These include 2-ethylisohexanol, nonyl alcohol, 2,2,4-trimethyl-1, 3-pentanediol and neopentyl glycol. Isobutyronitrile is obtained by the reaction between isobutyraldehyde and ammonia followed by dehydrogenation.

Propylene is indirectly associated with oxo alcohols through its dimer with butylenes (isooctyl alcohol), its trimer (decyl alcohol) and its tetramer (tridecyl alcohol).[10] These alcohols are mixtures of isomers because the olefins from which they are produced are mixtures. A typical amyl alcohol mixture may contain 60 percent 1-pentanol, 35 percent 2-methyl-1-butanol and 5 percent 3-methyl-1-butanol. The isooctyl alcohol mixture contains 26 percent 4,5-dimethyl-1-hexanol, 13 percent 3,5-dimethyl-1-hexanol, 18 percent 3,4-dimethyl-1-hexanol, 17 percent 3- and 5-methyl-1-heptanol and 9 percent other isomers. The composition is surprisingly uniform.

Esters of the lower molecular weight alcohols are

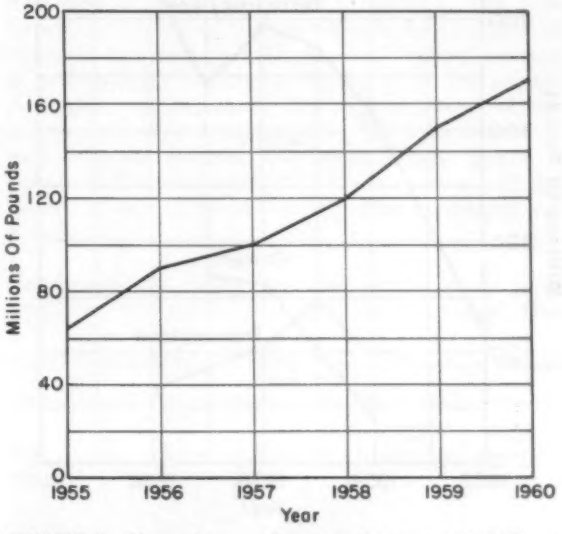


FIGURE 7—Shows the growth pattern for oxo alcohols, large users of propylene.

used as plasticizers for vinyl chloride resins, and tridecyl alcohol is used to produce detergents.[10] The future of oxo alcohols lies in the expansion of these uses and the development of others. Their growth pattern is given in Figure 7. The increase in oxo alcohol capacity has been almost explosive. Current capacity is 174 million pounds with another 246 million pounds announced. Five companies are now active in current production and in the projected increases in capacity.

Chlorination. Propylene will react with chlorine by addition to form propylene dichloride or by substitution to form allyl chloride.

Addition $CH_2=CHCH_3 + Cl_2 \rightarrow CH_2ClCHClCH_3$

Substitution

$CH_2=CHCH_3 + Cl_2 \rightarrow CH_2=CHCH_2Cl + HCl$

Propylene dichloride is produced by the addition of chlorine to propylene in either the vapor phase or the liquid phase at room temperature and it is a by-product of the chlorohydrination of propylene. Propylene dichloride is used in cleaning and scouring compounds and as a selective solvent, and it can be pyrolyzed to give good yields of allyl chloride. The annual production of propylene dichloride is not high.

The reaction of chlorine with propylene at temperatures above 300° C. becomes predominately one of substitution with allyl chloride as the main product. A typical reaction mixture may contain 85 percent allyl chloride, 2.3 percent 2-chloropropene, 6.5 percent 1,3-dichloropropenes, 2.6 percent propylene dichloride, 0.8 percent 2,3-dichloride-1-propene and 2.8 percent tri-

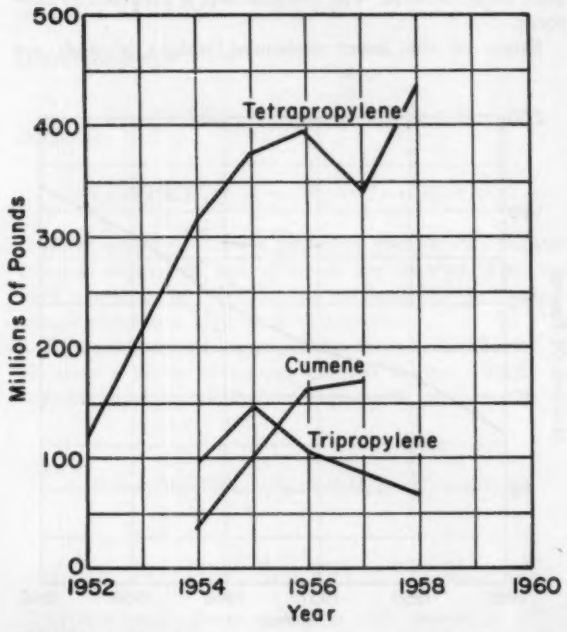


FIGURE 8—Here is the production rate for other important chemicals from propylene.

chlorides and others. Allyl chloride is used in the noted Shell process for the synthesis of glycerol from propylene. It is also used to product allyl alcohol for plastics and epichlorohydrin ($CH_2ClCHCH_2$, with O) for epoxy resins.

The epoxy picture is very confusing. In 1957 there were 40 million pounds produced and about 28 million pounds sold. The production for 1958 is estimated at 48 million pounds.[11] This modest growth pattern is in contrast to the optimism of those close to the epoxy market. Their estimates for 1961 production vary from 75 million pounds to 400 million pounds.[12] Four hundred million pounds of epoxy resins will require a lot of proylene. Epoxy resins are formed from epichlorohydrin and Bisphenol A which is a condensation product of phenol and acetone. Both the acetone and the epichlorohydrin are propylene derivatives.

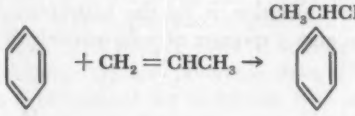
Oxidation. Information about the vapor phase oxidation of propylene to acrolein comes mainly from the patent literature.[13]

$$CH_2=CHCH_3 + O_2 \rightarrow CH_2=CHC(=O)-H + H_2O$$

While this source of information is not particularly satisfactory it does serve to set operating limits. The gas phase oxidation may be carried out over a cuprous oxide catalyst on silicon carbide at 348° C. and *ca.* 150 psi in the presence of steam and with a contact time of 0.8 sec. These conditions give a 6 to 7 percent conversion of propylene per pass and a 86 percent yield. The competitive method for acrolein production involves the catalytic vapor phase condensation of acetaldehyde and formaldehyde at about 300° C.[15]

Acrolein has a carbon-carbon double bond and a carbonyl group and these functional groups represent a great potential for synthesis. This potential has been slow to develop because acrolein is unstable, flammable and toxic and it has a strong, pungent odor and is extremely irritating to the eyes. In spite of these disadvantages acrolein has been available in quantity since 1952 and the first tank car of an acrolein derivative (1,2,6-hexanetriol) was shipped in 1955. Other commercial derivatives include methionine, acrolein dimer, allylidene diacetate, 2-ethoxy-3,4-dihydro-2H-pyran, glutaraldehyde, 2-hydroxyadipaldehyde, methacrolein and 1,5-pentanediol.[14] Acrolein is also used to produce allyl alcohol and acetone through an oxidation-reduction reaction with isopropyl alcohol.

Alkylation. Benzene is alkylated with propylene to produce both cumene (isopropylbenzene) and diisopropylbenzene.



This vapor phase reaction takes place readily at 200° to 300° C. using a supported phosphoric acid catalyst and a pressure of 25 atms. Only a small amount of diisopropylbenzene is formed when the benzene-propylene ratio is 5 to 1. Liquid phase alkylation at 20° to 50° C. with

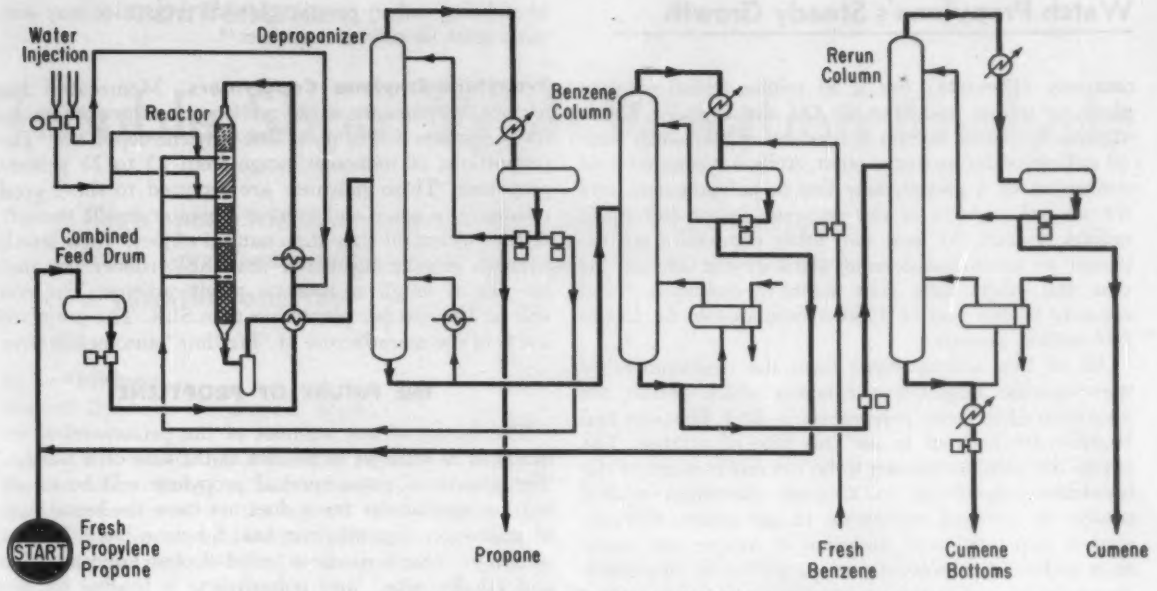


FIGURE 9—Specialty polymers of propylene can be made using this process.

88 to 90 percent sulfuric acid as the catalyst is of limited commercial interest. Both processes use refinery propane-propylene mixtures. Cumene is used to produce phenol and acetone and its annual production is given in Figure 8.

Pilot plant alkylation of benzene to a mixture of *m*- and *p*-diisopropylbenzene over a solid catalyst based on silica-alumina has been reported.[16] Separation of the two isomers presents no unusual problems. The meta isomer is oxidized to isophthalic acid for use in alkyd resin manufacture. *p*-Diisopropylbenzene is oxidized to terephthalic acid for synthetic fibers.

Alkylation of isobutane by propylene is of importance in the production of alkylate gasoline but the pentanes formed are not utilized by the petrochemical industry.

POLYMERIZATION

Heptenes. Heptenes are obtained by mixed selective polymerization with *n*-butylenes using a solid phosphoric acid catalyst under pressure. The composition of these heptenes is given in Table 1. The mixture is used as raw material for the production of isooctyl alcohol by the oxo process.

Tripropylene and Tetrapropylene. The trimers and tetramers of propylene are formed by the phosphoric acid catalyzed polymerization of refinery propylene. Two different supports have been used for the phosphoric acid. The Universal Oil Products Co. catalyst is phosphoric acid on Kieselguhr and operates between 200° and 250° C. at a pressure between 500 and 900 psi. The California Research Corp. catalyst is a thin film of phosphoric acid on crushed quartz. It is used between 150° and 200° C. at a pressure between 200 and 500 psi. Both catalyst produce a mixture of trimers and tetramers. A 75 percent yield of the tetramer may be obtained by recycling the tripropylene (Figure 9). Table 1 gives an indication of the complexity of the mixture obtained by this polymerization.

A typical tripropylene will boil between 258° and 296° C. Closer boiling cuts are available which contain up to 98 percent C_9 olefins. The trimers' use is closely associated with the production of decyl alcohol by the oxo process. The decyl alcohol is used in the production of plasticizers and detergents. Phenol is alkylated with tripropylene to produce nonylphenol which is treated with ethylene oxide (6 to 9 moles) to form an important nonionic detergent. These detergents have excellent emulsification and wetting power combined with low foam and good chemical stability.

A typical tetrapropylene mixture will have a boiling range of approximately 367° to 411° C. (90 percent). The types of olefins are shown in Table 1. The most important reaction of tetrapropylene is the alkylation of aromatic hydrocarbons and phenols. Alkylated benzene is used to make alkylaryl sulfonates which are anionic detergents. Approximately 500 million pounds of dodecylbenzene is produced annually. The alkylphenols are used to make nonionic detergents. Tetrapropylene is converted to tridecyl alcohol by the oxo process and this alcohol is used to produce high boiling plasticizers and detergents.

Polypropylene. Much has been written about polypropylene but not a great deal has been said. One

TABLE 1—Distribution of Olefin Types in Propylene Derived Olefins[5]

Type	Structure	Heptene	Volume Percent Tripropylene	Tetra-propylene
I	$RCH=CH_2$	1	1	2
II	$RCH=CHR$	12	14	10
III	$R_2C=CH_2$	11	8	7
IV	$R_2C=CHR$	54	35	26
V	$R_2C=CR_2$	22	42	55

company (Hercules) has a 20 million-pound-per-year plant on stream and Humble Oil and Refining Co. is expected to be on stream by the end of 1959 with their 40 million-pound-per-year plant. AviSun has announced conversion of a polyethylene line to polypropylene and the annual capacity of the converted plant will be 20 million pounds. At least two other companies are expected to announce definite plans by the end of the year and others have pilot plants in operation. Total capacity by the end of 1960 is estimated to be 150 to 200 million pounds.

All of this activity stems from the development of stereo-specific Ziegler-type catalysts which permit the formation of isotactic polypropylene. Both Hercules and Humble are licensed to use this type of catalyst. The key to the catalyst appears to be the replacement of the titanium tetrachloride in Ziegler's aluminum trialkyl catalyst by titanium trichloride. In one process this catalyst is suspended with exclusion of oxygen and water in a hydrocarbon solvent and propylene is then introduced.[16] Other catalysts are molybdenum oxide, cobalt molybdate and other molybdates supported on alumina, titania or zirconia (Standard Oil of Indiana). Several companies indicate that they have developed different catalyst systems. The whole area of patents and know-how is in for some exploration by patent lawyers before the dust settles.

Polypropylene's properties vary considerably with crystallinity, average molecular weight and molecular weight distribution.[17] Modulus of elasticity and yield strength increase with degree of crystallinity and other properties may depend upon how the material is processed. A rapidly cooled melt differs from a slowly cooled one. Brittleness is dependent upon both average molecular weight and crystallinity. A low molecular weight polypropylene with good flow properties may be brittle.

Polypropylene is said to possess a wider range of desirable properties than any single plastic yet developed. It is the lightest of all plastics (specific gravity 0.90) and it has outstanding ability to withstand boiling water temperatures for long periods of time. It has high rigidity, strength, resilience and relative hardness.

The uses of a polymer are a reflection of its properties. Injection molding and hot water piping are two immediate outlets for polypropylene with film and fibers the two greatest potential outlets. The films have good clarity and are strong and possess excellent dielectric properties. Producers of acrylic fibers say they are not worried because applications for acrylic fibers are too varied to be disturbed by the development of polypropylene fibers. Polypropylene fibers present dying problems but producers are confident that they will be overcome. There is still some question as to the general stability of polypropylene but it is claimed that this is no longer a problem.

Injection molded items on the market include hospital utensils (the cold bed pan is now behind us), pipe fittings, valves, refrigeration parts, automotive components, household equipment, business machine housings and parts and women's shoe heels. One potential producer apparently has a mote in his eye instead of stars. He is not interested at present because propylenes deficiencies in stability and in certain physical properties may seriously limit its ultimate markets.[18]

Propylene-Ethylene Copolymers. Montecatini has announced plans for a 120 million-pound-per-year plant for the production of propylene-ethylene copolymer. The proportions of monomer range from 25 to 75 percent propylene. These polymers are reported to show good resistance to aging and to have a greater tensile strength in the vulcanized state than natural rubber. Their tensile strength is generally better than SBR rubber but they are not as tough as isotactic polybutadienes. The cost will be 10 cents per pound less than SBR. The projected use is in the manufacture of "life-time" automobile tires.

THE FUTURE OF PROPYLENE

The future of any segment of the petrochemical industry is as difficult to predict as the way of a woman. The growth of petrochemical propylene will be steady but not spectacular for it does not have the broad base of utilization that ethylene has. Ethylene has 3 billion-pound-per-year derivatives (ethyl alcohol, ethylene oxide and ethylbenzene) and polyethylene is headed for the billion-pound class. Proplene has only 1 billion-pound derivative with no other derivative even close. Oxo alcohols and propylene based detergents are growing but they are still a long way off. The future of propylene may be with polypropylene and propylene-ethylene copolymer. Detergent uses of propylene tetramer show a respectable growth curve but foreign competition may take some of this away. The new process for the production of synthetic glycerol will not affect materially the over-all quantity of propylene converted to glycerol. The total production of glycerol has remained remarkably constant over the last few years—only the ratio of synthetic to natural has changed.

One of the attractive features of propylene is its low cost in respect to ethylene. This cost differential will become less favorable as the purity requirements increase. Polypropylene and other of the newer uses require high purity propylene.

New uses for propylene are needed and research will provide them. The propylene is available, it is up to the chemist to utilize it. An example is the reported new synthesis of acrylonitrile from propylene and ammonia as raw materials.[19]

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In maintenance . . .

Trouble Shoot With Vibration Analysis

High speed machines give refiners tough vibration problems. Five case histories show how they can be solved with a vibration analyzer

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AS THE SPEED of a rotating element is doubled, the centrifugal forces caused by such things as unbalance are increased as the square of the increase in speed. These increased forces can cause bearing failures and the possibility of other serious machinery failures.

Vibration Tolerances. In order to correlate the increased forces with the parameters of vibration (amplitude, frequency and phase), it becomes necessary to set up vibration amplitude tolerances in relation to the various frequencies. The development of vibration tolerance charts, as illustrated in Figure 1, is a result of experience gained with particular machines. Most machines would take the general shape of the curves in Figure 1. These are not absolute values. However, they will give the maintenance engineer a guide to what might be tolerable in machinery.

It will be noted in Figure 1, for example, that the same amplitude of vibration at 3,600 rpm may not be acceptable at 10,000 rpm. Also the rigidity of a system must be taken into account when using such a table. For example, a very flexible system for the same energy level of unbalance would indicate more amplitude than a rigid system. Bearing clearances can also vary, which will allow a rotating element that is out of balance to "whirl" in a larger circle. This "whirl" in most applications would be elliptical, since the rigidity of machines is usually greater in one direction than in another. The operator taking vibration readings could expect a different reading in amplitude when probing vertically than when probing horizontally. It is, therefore, imperative to label vibration direction as well as the point, amplitude, and frequency.

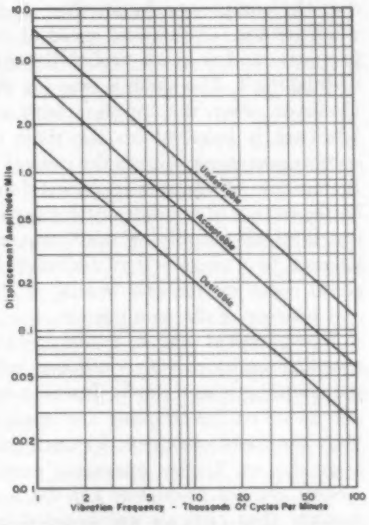

FIGURE 1—Vibration tolerance charts guide the allowable vibration for various frequencies.

Example. The first example of practical vibration analysis concerns a 2,500-horsepower, very-low-pressure turbine turning a hydrogen compressor on a Platformer. In this type of unit which is of variable speed, problems resolving themselves around natural frequencies of shaft, couplings and bearing supports can be expected.

The turbine rotor weighed approximately 1,400 pounds on this unit and the critical speed was approximately 5,600 rpm for the turbine rotor. The unit was designed to turn at 10,400 rpm with an overspeed trip-out at a little over 11,000 rpm. The unit could be made to operate quite satisfactorily at 9,600 rpm and below. However, as the speed approached 10,400 rpm a very severe vibration developed in a vertical direction on the bearing support at the exhaust end of the turbine. This unit was investigated and the bearing support in the turbine area was found to be resonant in a vertical direction when the unit was coupled at just about 10,400 cycles per minute. This bearing support had a slight overhang and was welded to the case which was about ⅝-inch steel plate.

By increasing the rigidity of the support in a vertical direction, the problem of severe vibration was reduced materially, so the unit could be operated at the designed rpm. Since the plate offered very little damping, this appeared as a rather sharp critical frequency. This was detected by a rapid increase in amplitude as the critical frequency was approached, and a decrease as the critical was passed. Taking simultaneous readings of phase, a rapid, practical 180-degree phase shift occurred from about 1,000 rpm below the critical frequency to the trip-out speed which was about 1,000 rpm above the critical frequency.

Case Two involved a 7,000-hp turbine driving an air compressor. There had been several occurrences of vibration in this unit together with excessive maintenance on the coupling between the turbine and compressor. In order not to interrupt the continuous service of this unit, it was desirable to attempt to locate the cause of vibration while the machine was running. It was checked with a vibration analyzer and a fairly strong component of vibration was detected at twice the rotational frequency in a vertical direction. By strong is meant—a

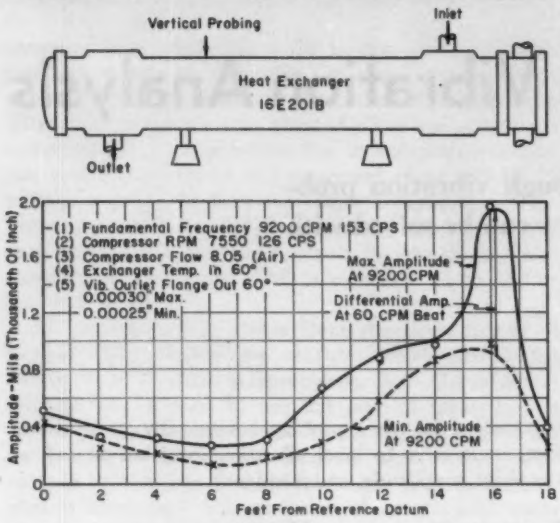

FIGURE 2

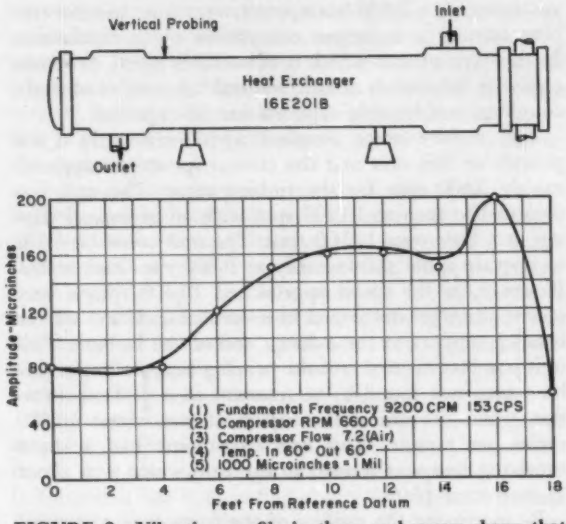

FIGURE 3—Vibration profile in these exchangers shows that severe vibration was aerodynamic and not related to compressor.

relatively high amplitude in comparison with the fundamental rotational amplitude of vibration.

Generally speaking, it has been found that when the amplitude of vibration at twice the rotational is in the neighborhood of 10 to 15 percent or over of the fundamental rotational frequency amplitude, misalignment can be suspected in a system. As this was the case, an attempt was then made to find why misalignment should occur in the system. It was found that insufficient provision had been made for expansion of the compressor discharge line.

Case Three is a somewhat unique application of vibration analysis equipment. This dealt with a new Platformer installation that was being air dried. When the flow in the heat exchangers was increased to a certain rate, the last two heat exchangers in the series developed a tremendous noise. These two heat exchangers were not lagged; therefore vibration readings were possible along the exchanger shell. It was thought that possibly this was related to the compressor rpm. The problem was to determine if the noise was caused by aerodynamics or to some relationship of the compressor speed.

The vertical vibration profiles for different flow conditions are recorded in Figures 2 and 3. It will be noted that in Figure 3 the fundamental frequency of vibration as detected was exactly the same as in Figure 2. This was conclusive proof that the source of the noise was definitely aerodynamic and not related to the compressor. The installation engineers made a calculation of the air that existed in the system under the specified pressure and flow conditions and compared it with the projected use of hydrogen in the system. It was determined that because of the entirely different characteristics of hydrogen, the aerodynamic vibration would disappear with the use of hydrogen.

Hydrogen was put in the system, and the heat exchangers then operated very quietly.

Case Four. Another case that was analyzed in a refinery resolved itself around vibration that was occurring in a large 1,500-hp, four-pole electric motor driving the air compressor for a cat cracker. Very serious vibration was occurring at about the rated motor speed. The filter on the vibration analyzer was tuned to the maximum amplitude at the approximate speed of the motor. The frequency meter could not be read closer than about 2 percent; however, when the shaft of the motor was observed under the strobe light which was being fired automatically at the frequency indicated on the pickup, the shaft was observed to be rotating. This immediately indicated that the vibration was not caused by a mechanical imbalance in the motor but to an electrical condition. The actual rotation observed under the strobe light was the slip of the motor. Several bars in the unit's rotor were found at one point to have failed in the connecting copper.

Case Five. An area which could become extremely troublesome to a refinery engineer or an installation engineer on really high speed equipment could be caused by the following situation: for example, a turbine with a flexible shaft driving a compressor with a flexible shaft through a coupling. The turbine is supplied by one vendor, the compressor by another, and the coupling by a third vendor. The critical speed of the turbine is known precisely, and is in all probability stamped right on the turbine itself. The same is true for the compressor rotor. However, when the coupling with a varying amount of lubricant is installed on the shaft of the turbine and compressor, in most cases the critical speed is not known. In the case of variable speed machinery, this could well be the source of another critical speed. This could manifest itself by amplifying small vibrations caused by unbalance to a degree that excessive wear and vibration could occur on the end bearing of the turbine and the end bearing of the compressor.

The practical way to determine the resonance of the coupling under actual conditions with the lubricant in the coupling is as follows: Install a small exciter of variable speed on the coupling and apply a vibration pickup. Vary the speed of the exciter until the amplitude reaches a maximum. Under operating conditions, this experimental critical frequency can be avoided in the same manner that criticals are avoided in operation of the turbine or compressor unit or another size coupling could be installed with a different mass critical. ##

Applied Hydrocarbon Thermodynamics

Part 12: Equilibrium Flash Vaporization Correlations for Petroleum Fractions

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KNOWLEDGE OF VAPOR-LIQUID phase equilibria conditions of petroleum fractions is essential for the design of most petroleum process equipment. This information can be obtained experimentally by determining an equilibrium flash vaporization (EFV) on the stock in question at the desired pressure. However, this procedure generally requires a considerable amount of time and money. For this reason, empirical correlations have been widely used for predicting the EFV data from the simpler analytical ASTM or TBP distillations.

Many correlations relating the three distillations, ASTM, TBP, and EFV at atmospheric pressure have appeared in the literature.[10, 19, 26, 29, 32, 35] However, none of these methods are sufficiently complete to permit making phase equilibrium calculations for all operating ranges of temperature and pressure encountered in petroleum distillation. This, and the following installment, presents empirical correlations which can be used to predict phase relationships over a pressure range of 10 mm Hg to the focal point. These correlations were developed from published data as well as data obtained at the Richmond Laboratory of California Research Corporation.

Correlations Developed. Two sets of charts have been developed for predicting the equilibrium phase relationships for petroleum fractions over a pressure range from 10 mm Hg to the focal point. One set predicts the phase relationships for atmospheric and higher pressures, while the other predicts the phase relationships in the vacuum region. The relationships were developed from stocks of continuous boiling range. No stocks with discontinuous TBP yield temperature relationships were included.

The empirical correlations given here for atmospheric and higher pressures are improvements over similar correlations given previously, while the correlations for vacuum conditions, to be given in the next installment, extend the application of this empirical technique down to 10 mm.

A schematic diagram, illustrating the interrelationship between atmospheric and 10 mm Hg distillations, is shown in Figure 12.1 with chart numbers indicated on the various routes.

The average deviation of these charts from all available experimental data ranges from 4° F to 10° F. These charts are consistent and can be used satisfactorily for process design work. Detailed evaluations of these charts are given.

This material is included in an applied thermodynamics series because it represents an alternate and practical method of solving the type of problems (i. e., phase equilibria) that are solved by the use of thermodynamics for simpler mixtures than petroleum fractions. In addition, it forms a basis for relationships to follow in future installments.

Sources of Data. Literature references are given at the end of this installment for the empirical correlations for the atmospheric, vacuum and the high pressure EFV curves. References are included for the TBP correlations and also for the theoretical methods of calculations. These items are covered in Parts 13, 14, and 15. A key to these references is given in Table 12.1. Three categories of literature are shown: (1) Experimental Data, (2) Empirical Correlations, and (3) Theoretical Methods. References giving data and correlations are divided according to pressure, i. e., atmospheric, superatmospheric, and vacuum.

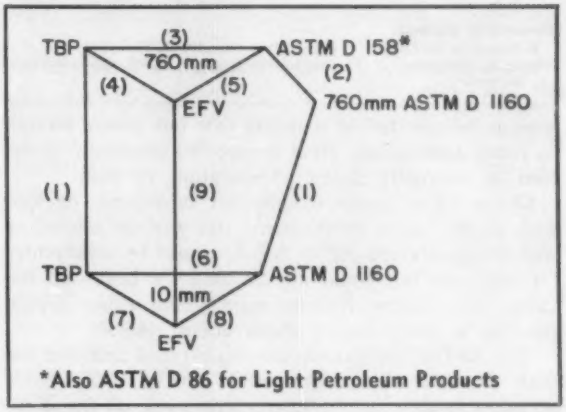

FIGURE 12.1—Interrelationships between empirical correlations relating ASTM-TBP-EFV at 760 and 10 mm Hg pressure.

Route	Figure	Remarks
1	13.1	Applicable for all stocks
2	13.2	Applicable for gas oil only
3	12.4 and 12.5	Applicable for stocks with normal boiling points up to about 800°F
4	12.6 and 12.7	
5	12.8 and 12.9	
6	13.3	Applicable to heavy stock
7	13.4 and 13.5	
8	13.6 and 13.7	
9	13.8	Applicable to all stocks

Two types of distillation data were used in developing these empirical correlations, namely, (1) analytical distillations and (2) equilibrium phase separations. The first are batch distillations run for the purpose of defining the mixture while the second are continuous distillations yielding vapor and liquid products that are in equilibrium with each other.

Examples of these two types of analytical distillations are:

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ASTM Assays
- D 86 for light petroleum products
- D 158 for gasolines through light gas oils
- D 1160 at 760 mm for middle oils
- D 1160 at 10 mm for heavy oils

TBP Distillations
- Podbielniak Hypercal
- Oldershaw column
- Spinning auger or band

Equilibrium phase separations for petroleum fractions are generally run on once-through flash vaporization units operated at a steady rate but slowly enough to reach equilibrium. Heat is supplied externally to the feed or internally during vaporization, or both.

TABLE 12.1—Key to Literature References on EFV and TBP Distillations

	Atmospheric Pressure	Super Atmospheric	Vacuum
Experimental Data EFV Curves	1, 5, 9, 10, 13, 20, 21, 22, 28, 31, 33, 34	1, 9, 10, 20	5, 14, 27, 28 30, 33, 36
TBP's for Feed	16, 24		15
ASTM's or TBP's on Equil. Products	9, 10, 13	9,10	
Empirical Correlations ASTM-TBP	2, 10, 11, 24		2
ASTM-EFV	6, 10, 11, 25, 29, 31, 32 35	10, 11, 19	
TBP-EFV	10, 11, 19		25, 26
Theoretical Methods K-Values for Oil Cuts	← 19, 25, 37 →		
Integral Calculation Methods	← 3, 4, 7, 8, 12, 17, 19 →		

Other vapor-liquid equilibrium measuring devices, such as the vapor recirculating still and the stirred or rocked equilibrium cell or bomb, would be satisfactory for light oils but could not be used for heavy oil because their longer holding time would cause coking troubles at temperatures above about 700° F.

The ASTM distillations are more rapid and cost less than the TBP distillations, while the latter are more accurate in defining the characteristics of oil fractions. ASTM's are frequently the only distillations obtained so they must be included in the correlations, however.

TBP distillations usually require larger samples, the size depending upon the size of the TBP still and column. When gravities of small (5 or 10%) cuts from a TBP are desired, the sample and apparatus sizes must be larger. Sample requirements for analytical tests must be considered in selecting the apparatus for the flash vaporization runs.

The EFV apparatus must be large enough to give equilibrium vapor and liquid of sufficient quantities for the desired analyses. On the other hand the EFV apparatus should be as small as possible to minimize the apparatus cost, the time required to reach equilibrium, the heat losses and the volumes of oils handled.

Vapor-liquid equilibrium measurements can be made for oil fractions with a small sample in a PVT (pressure, volume, temperature) apparatus. The smallest scale PVT apparatus is a small bore high pressure glass capillary tubing, in which the sample is stirred by a small steel ball that is moved up and down by an outside magnet. This is the apparatus used by Bahlke and Kay[1] in phase determinations for a gasoline and a naphtha. Properties of the equilibrium vapor and liquid were not included.

This small-scale PVT apparatus can be operated at high pressures and temperatures with good reproducibility to make bubble and dew point observations. The fraction vaporized at intermediate temperatures may be measured, also, in this type of PVT apparatus. These intermediate observations are of limited value, however, as the measured volumes of vapor and liquid are of unknown compositions, densities, and molecular weights. When samples of the equilibrium vapor and liquid can be taken from a PVT apparatus and analyzed, the partially vaporized experiments on the PVT apparatus can yield useful data. Sampling is not possible on most PVT apparatus, however.

Because of the requirement for samples and their analyses, vapor-liquid phase equilibria determinations for petroleum fractions are obtained in larger apparatus. The once-through EFV still is the most frequently used.[9, 10, 13, 21, 22, 27, 29, 30, 32]

As mentioned above, the once-through equilibrium flash vaporization still may have external feed preheating, internal heating, or both. Two of the above nine references used internal heating[22, 32] in the EFV still, while all the others have feed preheating and only enough heat addition to the still to compensate for heat loss.

As can be seen by the reference key in Table 12.1, most of the published experimental EFV data are for atmospheric pressure and vacuum conditions. Very few high pressure EFV data are available. Another deficiency in the data available for correlation development is the lack of data on the properties (gravities and ASTM or TBP distillations) of the equilibrium vapor and liquid. Without this information on the EFV products it is not possible to convert flashed products from the observed quantities of liquid and vapor to weight (pounds or pound moles) quantities. Because of these and other deficiencies in the data, the empirical correlations developed from these available data will be approximations, to be used only when observed EFV data are not available.

Empirical EFV Correlations. Empirical correlations for the prediction of equilibrium flash vaporization conditions (percent vapor at given temperature and pressure) are based on either of the analytical distillation curves, i.e., the ASTM or the TBP.

All three distillations (ASTM, TBP, and EFV) may be plotted on the same coordinates, i.e., temperature vs percent vaporized. Each ASTM or TBP curve on these scales represents a single batch distillation of the feed stock. An EFV curve on these scales, represents a series of equilibrium separations, from 0% to 100% flashed.

Another difference between these curves is the fact that the EFV curves must be determined or estimated at many pressures, as required; whereas, the ASTM and TBP distillations are run at atmospheric pressure only, except for special reduced pressure assays that will be discussed in Part 13.

These three atmospheric pressure curves are shown in Figure 12.2 for a naphtha-kerosine blend. The higher pressure EFV curves are included to complete the illus-

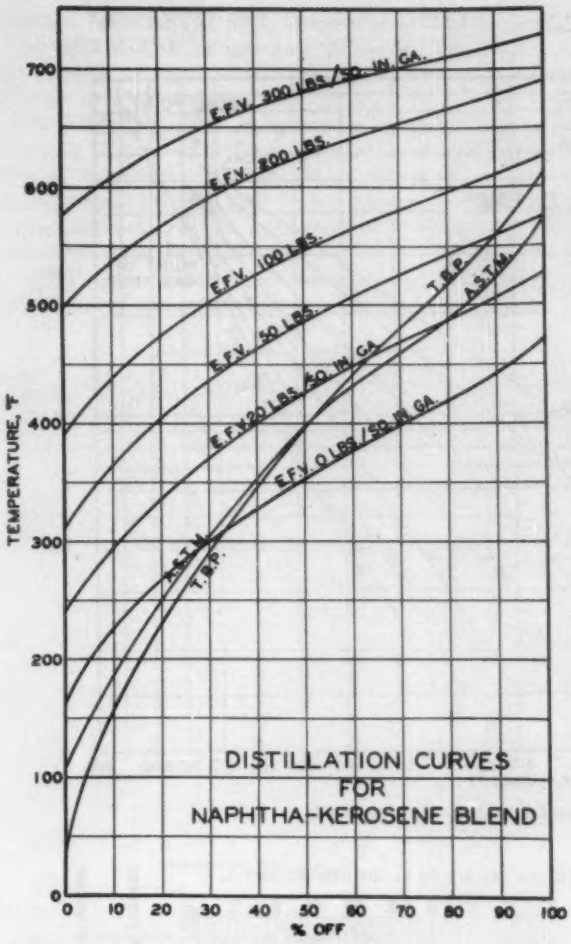

FIGURE 12.2—Distillation curves for naphtha-kerosine blend.

tration. Figure 12.2 is typical of plots obtained by plotting similar data for oil fractions.

The fact that the three atmospheric pressure distillation curves always intersect with the EFV curve having the flattest slope and the TBP the steepest slope, suggests an empirical correlation method. An atmospheric EFV curve can be drawn for an oil from the ASTM or TBP with two empirical correlations, one to locate a key point on the EFV and another to give the EFV slopes.

An examination of the vertical displacement of the higher pressure EFV curves on the temperature scale of Figure 12.2 suggests using the Cox Vapor Pressure plot (i.e., log vapor pressure versus reciprocal absolute temperature plus a small constant) for constructing the PTX (pressure, temperature, percent vaporized) phase diagram for petroleum fractions.

Figure 12.3 is a phase diagram for the same petroleum fraction represented by the distillation curves of Figure 12.2, i.e., the naphtha-kerosine blend. This plot is typical of the phase diagrams that are obtained for petroleum fractions. On these coordinates, the lines are straight and intersect at a focal point, which is above the critical point. The EFV curves on Figure 12.2 are cross-plots of constant pressure paths drawn across the phase diagram of Figure 12.3.

It will be noted that the bubble and dew point lines on Figure 12.3 fan out at lower pressures. Although these lines are straight on Figure 12.3, they should not be extrapolated to vacuum conditions.

Piromoov and Beiswenger[31] developed the first such empirical correlation thirty years ago, using experimental "pipe still" or EFV distillation data on oils. In this correlation the EFV curves were assumed to be straight on the temperature versus percent vaporized scales. This early work also assumed that the higher pressure EFV curve had the same slope as the atmospheric curve. Both of these assumptions were over simplifications.

In their 1948 correlation, Edmister and Pollock[10] avoided these simplifications in developing a method that has been widely used. This method was included in the previous PETROLEUM REFINER series with workable scale charts. This method was developed from experimental data on fractions of Mid-Continent crudes. The atmospheric true boiling point 50% temperature data ranged from 150° F to 700° F. Flash conditions ranged from 0 to 300 psig and from 120° F to 860° F. The correlations presented in this installment are similar to those of Edmister and Pollock[10] except that improvements were made to the high temperature portion of the three-way correlations relating TBP, ASTM, and EFV 50% temperatures at atmospheric pressure. These improvements were based on additional experimental data on high boiling fractions obtained in the Richmond Laboratory of California Research Corporation.

ASTM-TBP-EFV Relationships. A three-way correlation between the atmospheric EFV curve and the ASTM and TBP distillations, also at atmospheric pressure, is the "keystone" of this empirical method. This is evident by the interrelationships shown in Figure 12.1 and by the distillation curves given in Figure 12.2.

The atmospheric pressure correlations given on Figures 12.4 through 12.9 are based on the 50% evaporated temperatures as the reference points on the ASTM, TBP and EFV curves. Temperature difference correlations for segments of the curves complete the representation of the distillation curves. Correlations for estimating the EFV 50% temperature and temperature differences from the corresponding ASTM, TBP values permit constructing the atmospheric EFV curves from the ASTM or TBP curves.

Figures 12.4 through 12.9 are recent revisions to the Edmister-Pollock correlations.[10,11] These revisions include: (1) more accurate ASTM-TBP 50% temperature relationship for the entire range and (2) improvement in the high temperature regions of the ASTM-EFV and TBP-EFV 50% temperature correlations, and (3) replotting the slope correlations as temperature differences for segments of the distillation curves to make these charts more convenient for use.

The high temperature range of the atmospheric 50% correlations and the low temperature range of the 10 mm 50% correlations (presented in the next installment) overlap each other by about 125° F. In this region of overlap these two sets of correlations are consistent. Thus, for stocks which fall in this overlap region, either the atmospheric or 10 mm 50% correlations may be used to give the same results.

The ASTM-TBP 50% temperature relationships given in Figure 12.4 is used to predict TBP 50% tem-

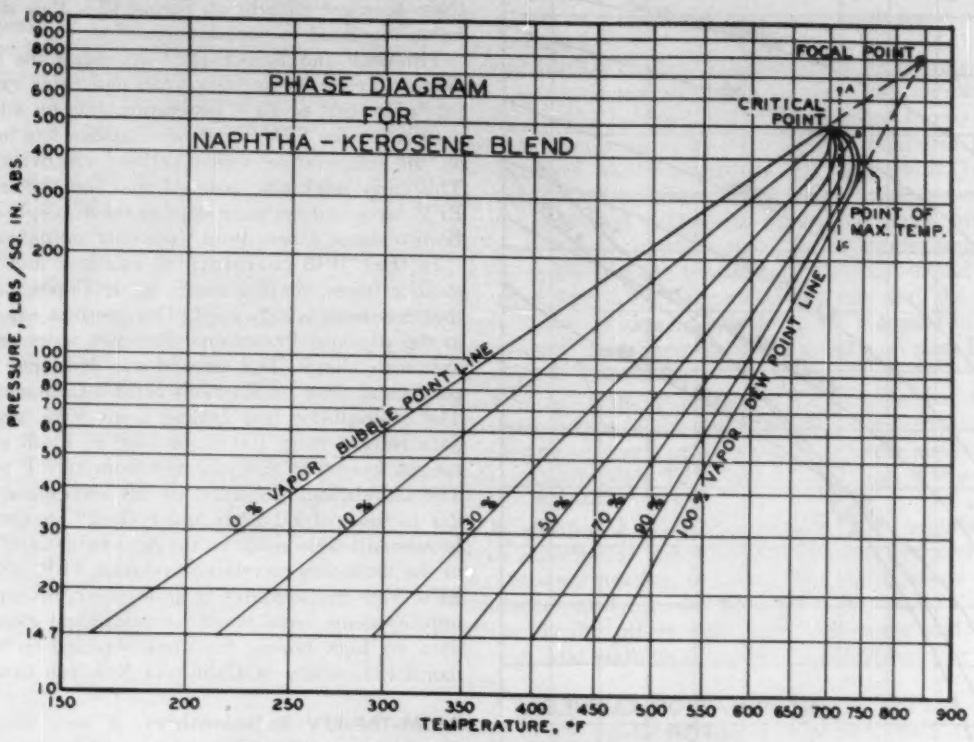

FIGURE 12.3—Phase diagram for naphtha-kerosine blend.

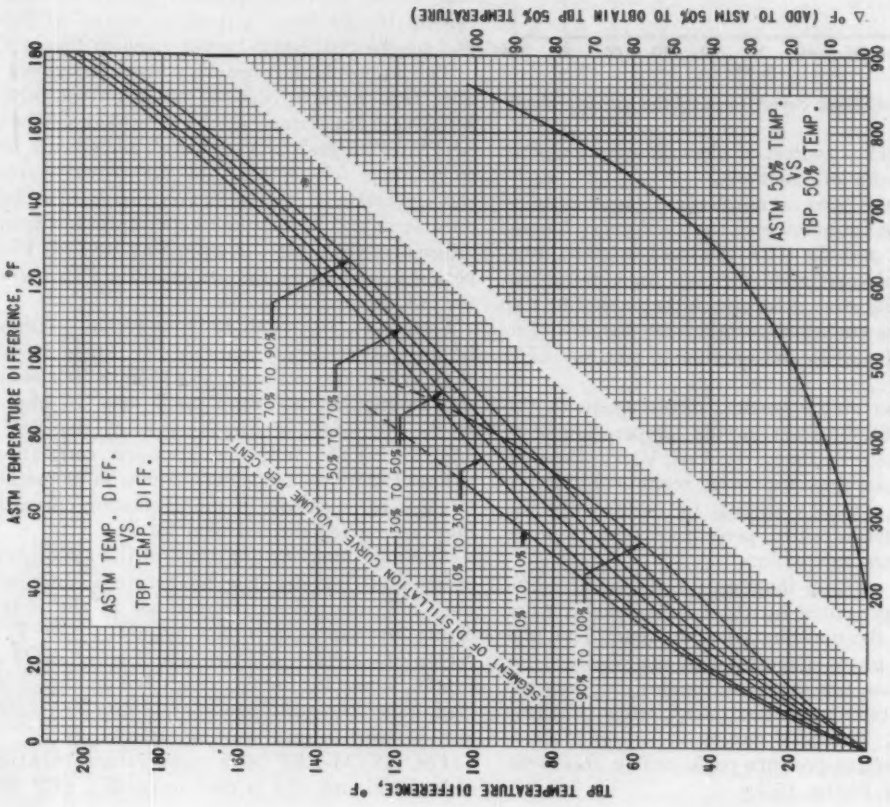
ASTM TEMP. DIFF. VS TBP TEMP. DIFF.
ASTM TEMPERATURE DIFFERENCE, °F
TBP TEMPERATURE DIFFERENCE, °F
SEGMENT OF DISTILLATION CURVE, VOLUME PER CENT
0% TO 10%
10% TO 30%
30% TO 50%
50% TO 70%
70% TO 90%
90% TO 100%
ASTM 50% TEMP. VS TBP 50% TEMP.
ASTM 50% TEMPERATURE, °F
Δ °F (ADD TO ASTM 50% TO OBTAIN TBP 50% TEMPERATURE)

FIGURE 12.4—(Lower right) ASTM 50 percent temperature versus TBP 50 percent temperature.

FIGURE 12.5—(top left) ASTM temperature difference versus TBP 50 percent temperature difference.

peratures from ASTM 50% temperatures. Figure 12.5 is the ASTM-TBP temperature difference correlation that should be used with Figure 12.4 in converting ASTM's to TBP's or vice versa.

The TBP-EFV 50% temperature relationship is shown in Figure 12.6. This correlation is similar to those of Edmister and Pollock[10] except some revision has been made below a TBP 50% temperature of 650°F to give somewhat better agreement with available experimental data. Also, above a TBP 50% temperature of 650°F some compromise was made in order that this portion of the correlation agree better with vacuum data on heavy stocks. Figure 12.7 is the TBP-EFV temperature difference correlation that is used with Figure 12.6 in estimating an EFV curve from the TBP.

The ASTM-EFV 50% relationship is shown in Figure 12.8. This correlation was developed to give a consistent three-way correlation relating the ASTM, TBP, and EFV 50% temperatures. Figure 12.9 is the ASTM-EFV temperature difference correlation that is used with Figure 12.8 in estimating an EFV curve from the ASTM.

Detailed evaluations of these six charts, Figures 12.4 through 12.9, have been made and are shown in Tables

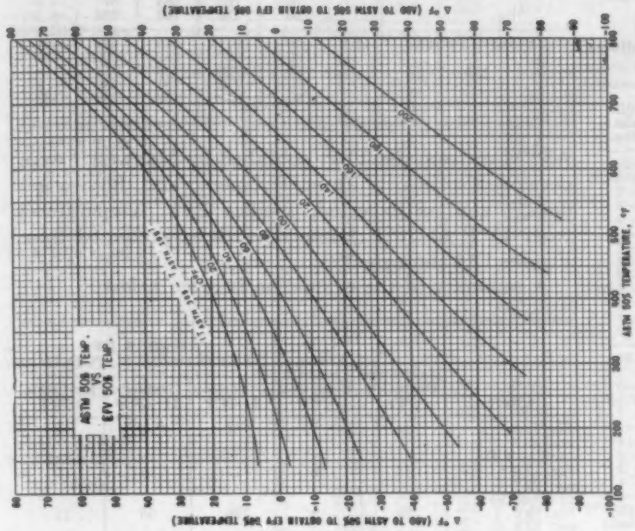

FIGURE 12.8—ASTM 50 percent temperature versus EFV 50 percent temperature.

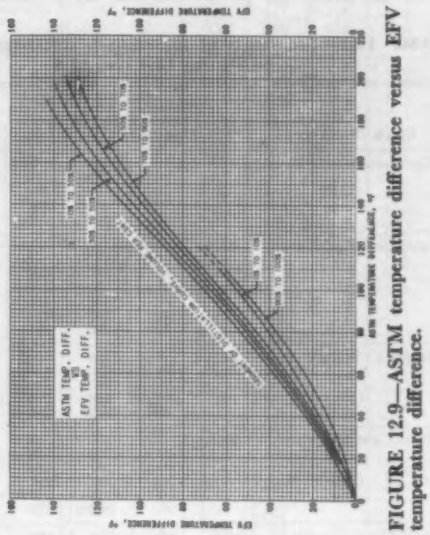

FIGURE 12.9—ASTM temperature difference versus EFV temperature difference.

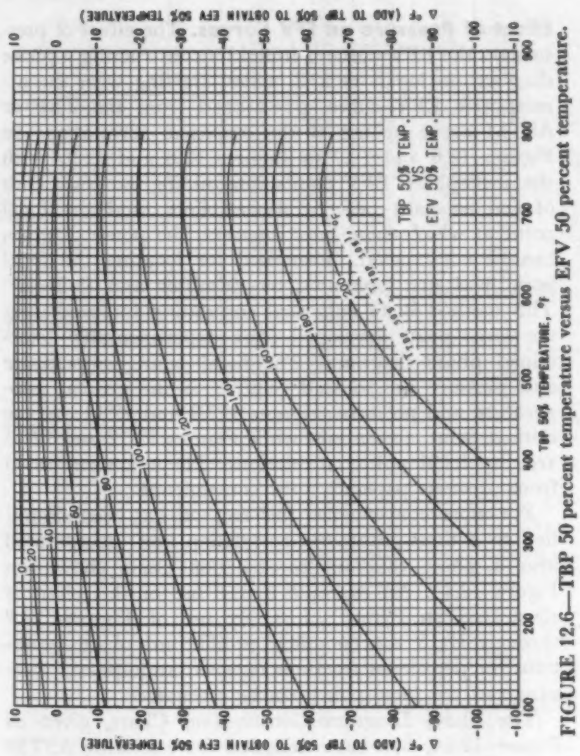

FIGURE 12.6—TBP 50 percent temperature versus EFV 50 percent temperature.

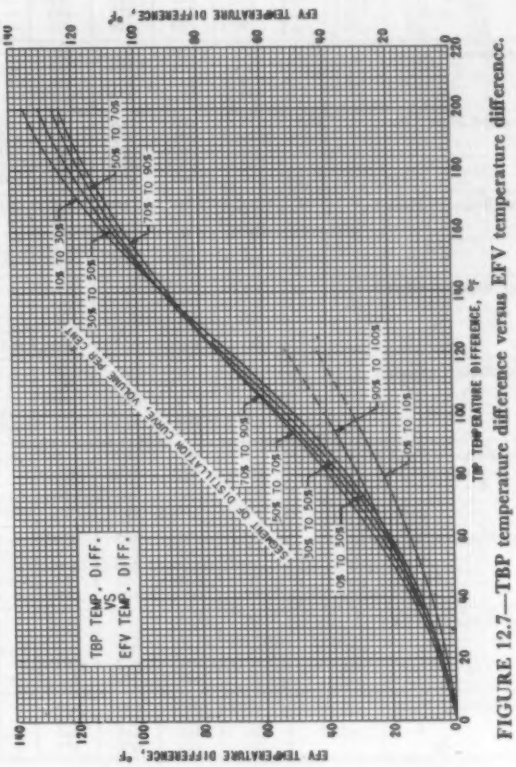

FIGURE 12.7—TBP temperature difference versus EFV temperature difference.

12.2, 12.3, and 12.4. The evaluations were made using experimental data from four sources.[5, 10, 13, 34] The experimental EFV data of Piromoov and Beiswenger[31] were not included in the evaluation because the EFV temperatures were measured with thermometers, and no apparent stem corrections were made. Therefore, the reported EFV data are believed to be somwhat low. Also, the reported ASTM distillation was run by the Saybolt 10% distillation method which gives temperatures somewhat higher than the ASTM method. The Esso methods for predicting the EFV curve from the ASTM or from the TBP, published by Maxwell,[23] were developed primarily from Piromoov and Beiswenger data,[31] and as expected, predict EFV temperatures from 15°F to 20°F lower than those predicted from Figures 12.4 through 12.9.

A summary of the evaluation is given below.

TABLE 12.2—Evaluation of Atmospheric ASTM-TBP Correlation on Figures 12.4 and 12.5

Stock (Reference)	Gr. °API	Volume, Percent Distilled	Atm. ASTM Obs.	Atm. TBP Obs.	Atm. TBP Calc.	Diff. Calc.-Obs.
Naphtha-Kerosine Blend (10)	47.8	10	172	160	150	—10
		30	298	289	292	+ 3
		50	393	396	403	+ 7
		70	455	481	479	— 3
		90	516	559	550	— 9
Extraction Naphtha (10)	68.7	0	156	137	144	+ 7
		10	161	146	157	+11
		30	163	153	162	+ 9
		50	164	155	164	+ 9
		70	168	166	172	+ 6
		90	180	190	189	— 1
		EP	220	210	232	+22
Cleaner's Naphtha (10)	57.3	0	194	104	144	+40
		10	223	198	197	— 1
		30	241	240	232	— 8
		50	256	259	258	— 1
		70	272	289	282	— 7
Virgin Light Naphtha (10)	63.9	0	115	62	48	—14
		10	158	122	120	— 2
		30	197	185	183	— 2
		50	222	227	223	— 4
		70	248	257	261	+ 4
		90	292	325	315	—10
Virgin Heavy Naphtha (10)	49.2	10	318	303	304	+ 1
		30	328	327	326	— 1
		50	340	347	347	0
		70	355	376	370	— 6
		70	380	416	404	—12
Reformed Gasoline (10)	49.6	30	276	264	263	— 1
		50	312	318	317	— 1
		70	341	351	358	+ 7
		90	381	410	408	— 2
Treated Press. Dist. (10)	49.7	10	170	148	137	—11
		30	266	277	253	—24
		50	340	367	347	—20
		70	392	429	413	—16
		90	440	486	472	—14
Cal. Research Stock 1 (5)		10	140	90	106	+16
		30	170	155	158	+ 3
		50	188	192	188	— 4
		70	202	210	210	0
		90	220	232	235	+ 3
Cal. Research Stock 2 (5)		10	260	247	253	+ 6
		30	264	264	262	— 2
		50	270	278	273	— 5
		70	275	286	281	— 5
		90	283	307	292	—15
Cal. Research Stock 3 (5)		10	321	307	310	+ 3
		30	330	330	330	0
		50	339	347	346	— 1
		70	348	370	360	—10
		90	367	393	386	— 7
Cal. Research Stock 4 (5)		10	408	397	400	+ 3
		30	420	425	425	0
		50	430	447	443	— 4
		70	440	464	459	— 5
		90	456	490	481	— 9
Cal. Research Stock 5 (5)		10	482	462	473	+ 9
		30	505	511	516	+ 5
		50	518	540	539	— 1
		70	535	568	565	— 3
		90	560	603	599	— 4
Cal. Research Stock 6 (5)		10	473	450	455	+ 5
		30	512	518	518	0
		50	542	567	565	— 2
		70	567	602	601	— 1
		90	595	640	638	— 2
Cal. Research Stock 7 (5)	37.0	10	436	409	416	+ 7
		30	493	494	498	+ 4
		50	519	535	540	+ 5
		70	540	565	571	+ 6

TABLE 12.3—Evaluation of Atmospheric TBP-EFV Correlation on Figures 12.6 and 12.7

Stock (Reference)	Gr. °API	Volume, Percent Distilled	Atm. ASTM Obs.	Atm. EFV Obs.	Atm. EFV Calc.	Diff. Calc.-Obs.
Naphtha-Kerosine Blend (10)	47.8	10	160	214	214	0
		30	289	295	295	0
		50	396	352	355	+ 3
		70	481	399	397	— 2
		90	559	442	435	— 7
Cal. Research Stock 7 (5)	37.0	10	409	475	477	+ 2
		30	494	501	514	+13
		50	535	516	526	+10
		70	565	532	535	+ 3
Cal. Research Stock 8 (5)	22.4	0	462	606	600	— 6
		10	557	630	629	— 1
		30	617	652	649	— 3
		50	662	668	663	— 5
		70	705	684	677	— 7
		90	773	706	708	+ 2
Cal. Research Stock 9 (5)	26.0	10	574	640	654	+14
		30	660	682	692	+10
		50	720	718	714	— 4
		70	778	731	736	+ 5
		90	863	767	780	+13

Chart	Maximum Deviation (°F)	Average Absolute Deviation (°F)	NUMBER OF EXPERIMENTAL POINTS Deviation 0—10°F	Deviation 11—20°F	Deviation >20°F
Fig. 12.4 and 12.5 (ASTM-TBP)	24	7	59	9	2
Fig. 12.6 and 12.7 (TBP-EFV)	14	6	17	3	0
Fig. 12.8 and 12.9 (ASTM-EFV)	29	9	126	55	11

Effect of Pressure on EFV Curves. The effect of pressure on the EFV curve is found by constructing a phase diagram on log P vs 1/T scales, starting with the atmospheric EFV curve, predicted from the TBP or ASTM curve by use of the empirical correlations on Figures 12.6 and 12.7 or Figures 12.8 and 12.9. With the atmospheric EFV points determining the lower ends of the constant percent flashed lines, and the focal point at which these lines intersect, the phase diagram can be constructed. A method for locating the focal point was first presented by Edmister and Pollock.[10] This method is an empirical correlation for predicting the focal point developed from experimentally determined phase diagrams. The focal point temperature and pressure are located relative to the critical temperature and pressure. Figures 12.10 and 12.11 are the critical point correlations while Figures 12.12 and 12.13 are the focal point correlations. These are reprinted from previous papers[10, 11] for convenience.

For more convenience, this method has been simplified to a three-parameter correlation and incorporated into a phase diagram construction chart shown on Figure 12.14. An example in the use of this chart is illustrated on Figure 12.15. By use of Figures 12.4 through 12.15 the complete equilibrium phase conditions for petroleum fractions between atmospheric pressure and the focal point can be estimated.

The Phase Diagram Construction Chart, given as Figure 12.14, has been designed for use with ASTM

TABLE 12.4—Evaluation of Atmospheric ASTM-EFV Correlation on Figures 12.8 and 12.9

Stock (Reference)	Gr. °API	Volume, Percent Distilled	Atm. ASTM Obs.	Atm. EFV Obs.	Atm. EFV Calc.	Diff. Calc.-Obs.
WCE-DHP Stock 1 (10)		10	150	178	174	— 4
		30	200	208	204	— 4
		50	235	224	222	— 2
		70	268	245	238	— 7
		90	325	273	268	— 5
WCE-DHP Stock 2 (10)		0	203	258	260	+ 2
		10	255	278	283	+ 5
		30	292	301	304	+ 3
		50	315	314	315	+ 1
		70	339	327	326	— 1
		90	400	354	358	+ 4
		EP	475	380	391	+11
WCE-DHP Stock 3 (10)		0	300	344	345	+ 1
		10	327	354	356	+ 2
		30	358	371	374	+ 3
		50	375	380	382	+ 2
		70	393	388	390	+ 2
		90	415	400	399	— 1
		EP	438	405	405	0
WCE-DHP Stock 4 (10)		0	230	298	304	+ 6
		10	285	322	329	+ 7
		30	343	357	365	+ 8
		50	399	387	398	+11
		70	457	415	430	+15
		90	515	448	460	+12
		EP	568	472	479	+ 7
WCE-DHP Stock 5 (10)		0	388	448	451	+ 3
		10	424	457	466	+ 9
		30	450	472	480	+ 8
		50	473	483	491	+ 8
		70	498	496	509	+13
		90	540	519	529	+10
		EP	580	535	542	+ 7
WCE-DHP Stock 6 (10)		0	415	474	481	+ 7
		10	456	484	498	+14
		30	477	500	509	+ 9
		50	496	509	518	+ 9
		90	544	535	...	....
		EP	580	550	...	....
WCE-DHP Stock 7 (10)		0	432	484	491	+ 7
		10	462	498	503	+ 5
		30	485	508	516	+ 8
		50	503	517	525	+ 8
		70	520	526	533	+ 7
		90	550	540	547	+ 7
		EP	580	550	556	+ 6
WCE-DHP Stock 8 (10)		0	410	480	488	+ 8
		10	454	500	507	+ 7
		30	502	525	536	+11
		50	537	543	555	+12
		70	575	563	575	+12
		90	650	606	617	+11
		EP	730	648	654	+ 6
WCE-DHP Stock 9 (10)		0	507	570	584	+14
		10	535	585	595	+10
		30	571	600	616	+16
		50	597	611	628	+17
		70	630	628	644	+16
		90	685	660	672	+12
		EP	780	712	720	+ 8
WCE-DHP Stock 10 (10)		0	536	607	620	+13
		10	580	621	639	+18
		30	605	637	653	+16
		50	625	647	663	+16
		70	650	658	675	+17
		90	682	675	689	+14
		EP	720	691	701	+10
WCE-DHP Stock 11		0	570	644	664	+20
		10	612	660	682	+22
		30	645	678	701	+23
		50	670	692	714	+22
		70	700	707	728	+21
		90	756	739	757	+18
Pressure-Dist. (10)		0	50	140	...	....
		10	165	213	192	—21
		30	261	270	259	—11
		50	330	315	301	—14
		70	391	348	335	—13
		90	463	382	375	— 7
		EP	520	410	396	—14
Mid-Cont. Fraction (10)		0	250	320	316	— 4
		10	284	334	326	— 8
		30	330	358	354	— 4
		50	380	384	382	— 2
		70	442	418	417	— 1
		90	525	467	465	— 2
		EP	615	520	509	—11
Mid-Cont. Fraction (10)		0	280	352	364	+12
		10	327	380	385	+ 5
		30	408	424	439	+15
		50	490	472	491	+19
		70	584	527	551	+24
		90	706	603	632	+29
Treated Press. Dist. (10)	52.3	0	65	127	126	— 1
		10	141	175	164	—11
		30	244	237	237	0
		50	317	287	282	— 5
		70	378	325	316	— 9
		90	439	358	348	—10
		EP	493	390	368	—22
Naphtha Bottoms (10)	39.3	0	276	334	352	+18
		10	355	385	392	+ 7
		30	405	415	422	+ 7
		50	430	428	435	+ 7
		70	452	441	445	+ 4
		90	505	469	472	+ 3
		EP	561	491	491	0
Press. Dist. (10)	50.8	0	80	122	147	+25
		10	165	191	191	0
		30	258	254	255	+ 1
		50	321	292	293	+ 1
		70	382	326	327	+ 1
		90	432	358	352	— 6
		EP	500	384	380	— 4
Naphtha Bottoms (10)	44.2	0	170	260	246	—14
		10	258	300	292	— 8
		30	327	334	336	+ 2
		50	370	356	360	+ 4
		70	406	376	378	+ 2
		90	443	393	395	+ 2
		EP	500	410	416	+ 6
Mid-Cont. Gas Oil (10)	35.5	0	475	533	551	+18
		10	512	551	566	+15
		30	543	573	584	+11
		50	570	589	598	+ 9
		70	604	607	615	+ 8
		90	663	636	646	+10
		EP	730	665	673	+ 8
Mid-Cont. Gas Oil (10)	36.9	0	268	364	365	+ 1
		10	346	403	404	+ 1
		30	464	481	491	+10
		50	567	541	561	+20
		70	641	596	605	+ 9
		90	746	652	671	+19
		EP	804	683	693	+10
Winkler Gas Oil Naphtha Blend (10)	32.0	0	190	347	...	....
		10	319	385	373	—12
		30	432	457	455	— 2
		50	526	520	517	— 3
		70	612	571	571	0
		90	692	623	617	— 4
		EP	747	650	637	—13
Naphtha-Kerosine Blend (10)	47.8	0	96	160	158	— 2
		10	172	214	196	—18
		30	298	295	290	— 5
		50	393	352	353	+ 1
		70	455	399	388	—11
		90	516	442	420	—22
		EP	575	464	443	—21
Pipe Still Pressure Distillate (13)	50.3	10	165	203	185	—18
		30	287	276	275	— 1
		50	365	332	324	— 8
		70	428	372	360	—12
		90	500	403	400	— 3
Shell Still Pressure Distillate (13)	46.6	10	260	300	295	— 5
		30	367	360	371	+11
		50	431	400	409	+ 9
		70	468	430	428	— 2
		90	519	455	454	— 1
Stock No. 1 (34)	37.2	10	494	535	530	— 5
		30	517	549	543	— 6
		50	534	563	551	—12
		70	563	576	565	—11
		90	620	589	595	+ 6
		EP	703	615	634	+19
Stock No. 2 (34)	55.0	10	235	262	260	— 2
		30	259	273	273	0
		50	281	283	284	+ 1
		70	304	295	294	— 1
		90	327	313	304	— 9
Stock No. 3 (34)	48.0	10	264	315	300	—15
		30	316	337	332	— 5
		50	357	359	354	— 5
		70	395	380	374	— 6
Stock No. 4 (34)	43.0	10	382	409	413	+ 4
		30	394	415	419	+ 4
		50	410	422	427	+ 5
		70	426	428	434	+ 6
Stock No. 5 (34)	43.0	10	293	342	343	+ 1
		30	371	405	395	—10
		50	444	444	440	— 4
		70	516	481	482	+ 1
		90	589	518	523	+ 5

Table continued on following page

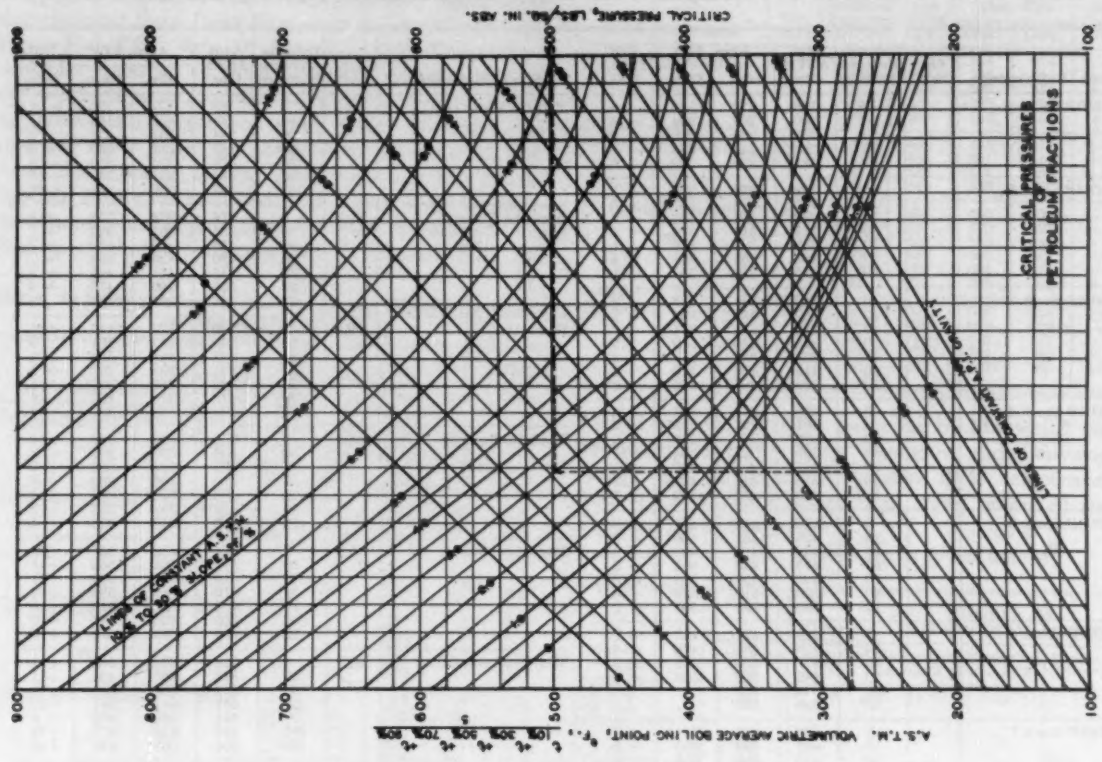
CRITICAL PRESSURE, LBS./SQ. IN. ABS.
CRITICAL PRESSURES OF PETROLEUM FRACTIONS
LINES OF CONSTANT A.S.T.M. SLOPE
LINES OF CONSTANT API GRAVITY
A.S.T.M. VOLUMETRIC AVERAGE BOILING POINT, °F.

FIGURE 12.11—Critical pressure of petroleum fractions.

TABLE 12.4—(Continued)

Stock (Reference)	Gr. °API	Volume, Percent Distilled	Atm. ASTM Obs.	Atm. EFV Obs.	Atm. EFV Calc.	Diff. Calc.-Obs.
Cal. Research Stock 7	37.0	0	330	437	424	— 7
		10	436	475	484	+ 9
		30	493	501	519	+18
(5)		50	519	516	532	+16
		70	540	532	542	+10
		90	568	546	554	+ 8
Cal. Research Stock 10	56.0	0	104	169	159	—10
		10	172	206	192	—14
		30	264	252	255	+ 3
(5)		50	309	277	280	+ 3
		70	323	295	286	— 9
		90	337	310	292	—18
		EP	369	316	302	—14

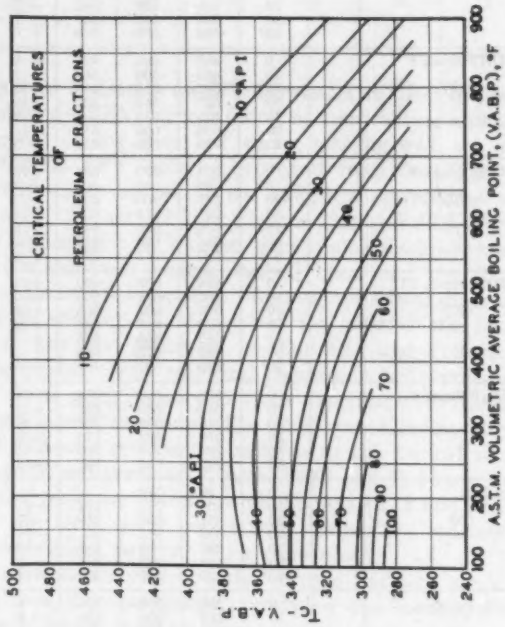

FIGURE 12.10—Critical temperature of petroleum fractions.

distillation data in predicting phase conditions of petroleum fractions at superatmospheric pressures. The VABP (volumetric average boiling point), the 10% to 30% differences and the 10% to 90% slope of the ASTM assay and the gravity are used in the calculations made by the use of this construction chart.

A calculation form in the upper left-hand corner simplifies the estimation of the atmospheric EFV, the VABP, and the ASTM slopes. Three-parameter, right-hand section of the chart is for locating the focal point. This focal-point location section was prepared empirically from the original method, i.e., Figures 12.10 through 12.13. This three-parameter focal point correlation on Figure 12.14 is more convenient than the four original charts method, but probably not as reliable. The example on Figure 12.15 shows the application of this construction chart for a gasoline.

For heavy stocks, the 90% evaporated point on the ASTM will not be available so this chart can only be used after extrapolating the ASTM to get the required properties. For the heaviest oils, such as reduced crudes, for which the 10 mm D 1160 distillation, rather than the atmospheric ASTM may be available, the phase diagram is required under vacuum rather than super-

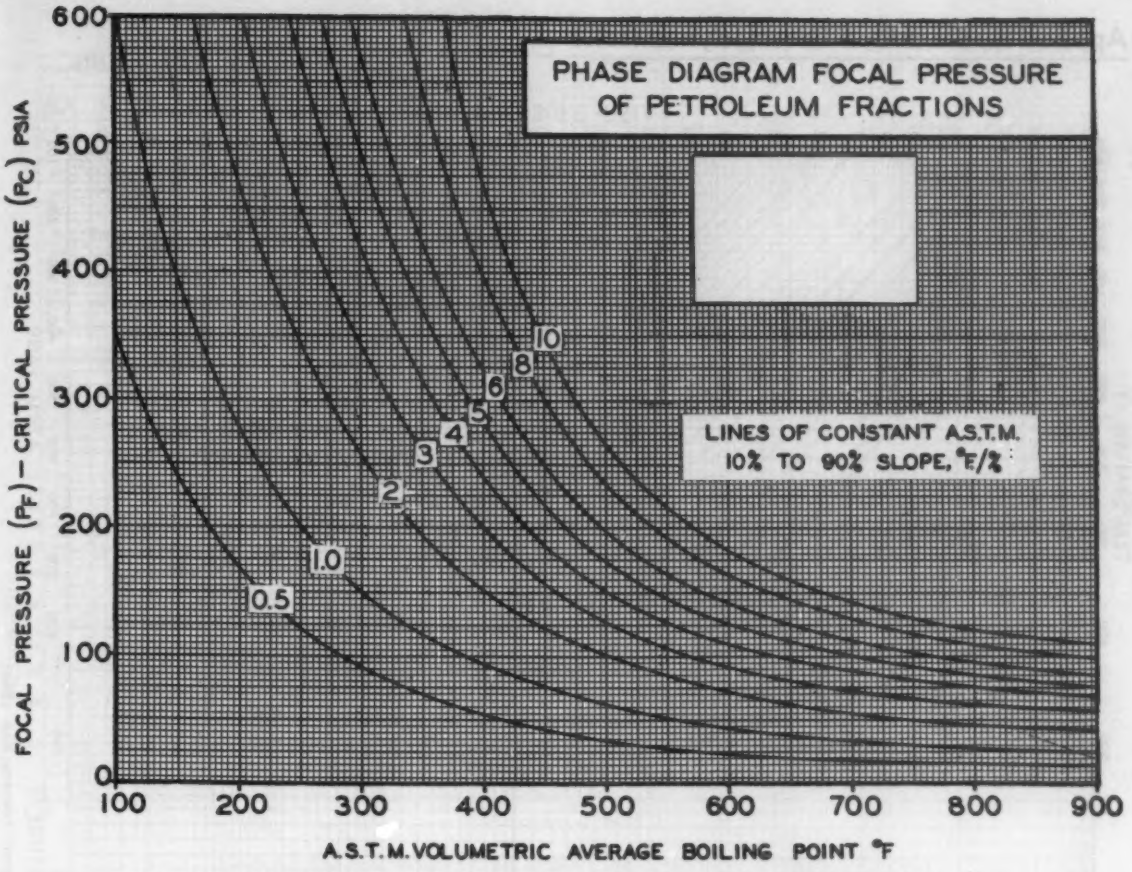

FIGURE 12.12—Phase diagram focal temperature of petroleum fractions.

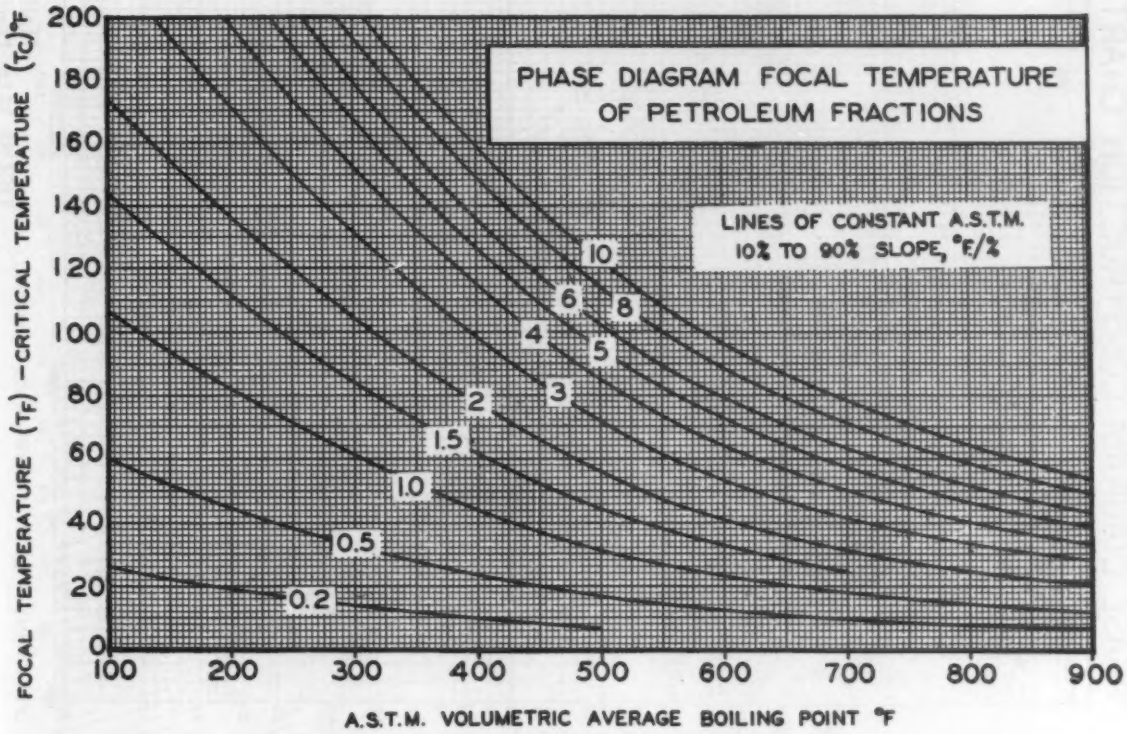

FIGURE 12.13—Phase diagram focal temperature of petroleum fractions.

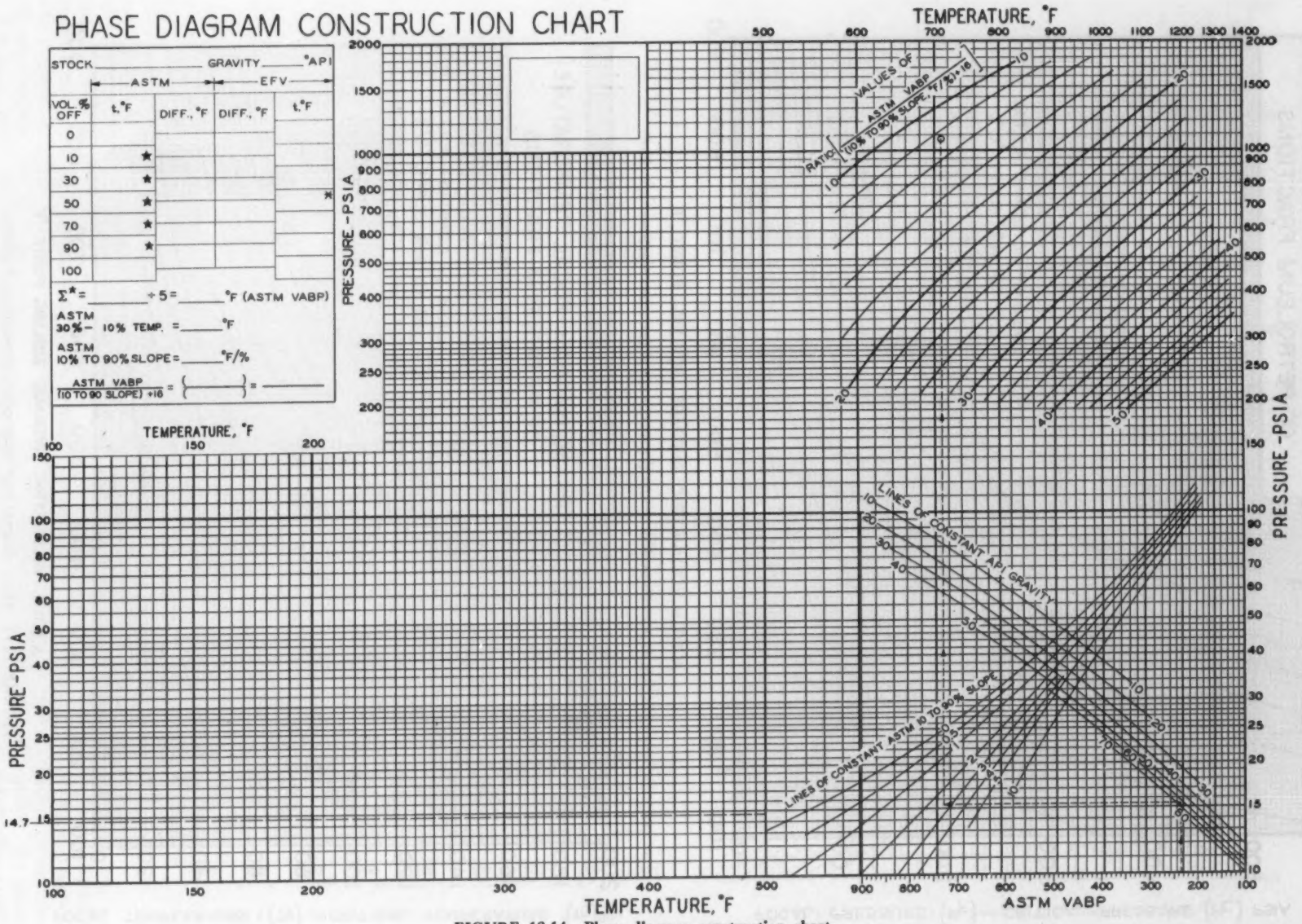

FIGURE 12.14—Phase diagram construction chart.

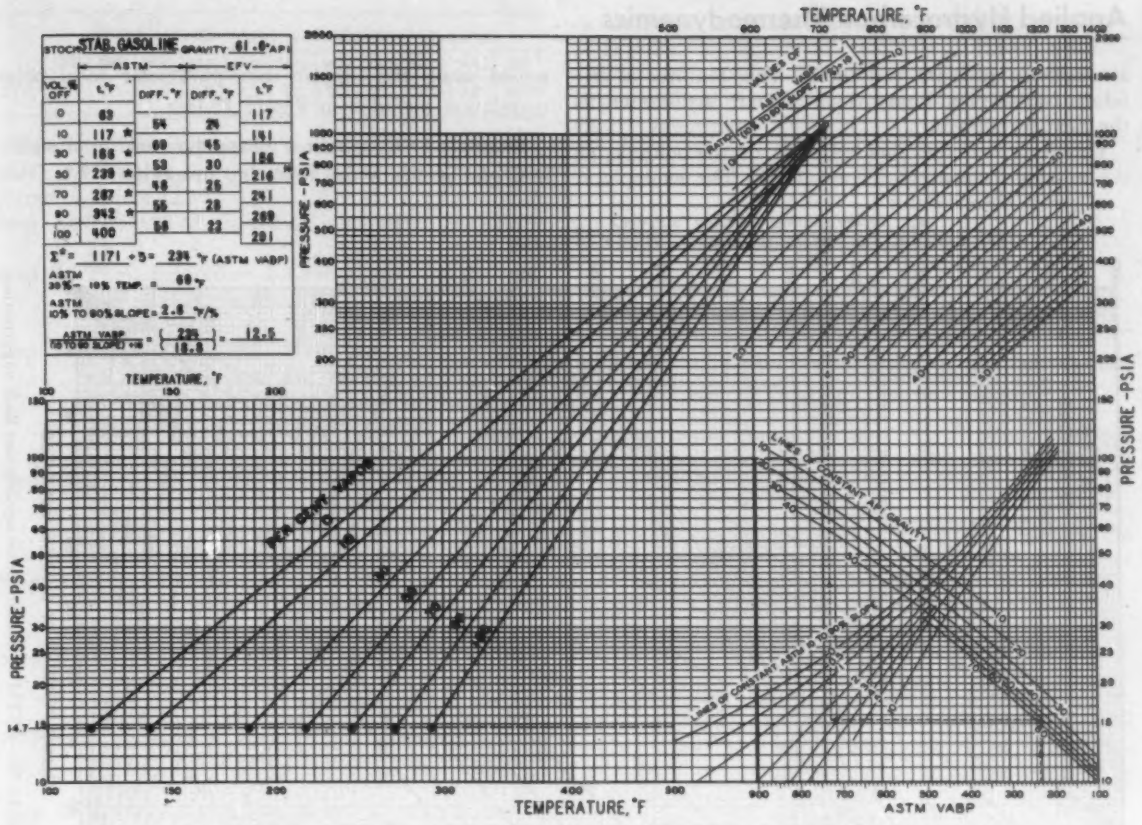
TEMPERATURE, °F
PRESSURE - PSIA
ASTM VABP
STAB. GASOLINE
Σ°= 1171 ÷5= 234 °F (ASTM VABP)
ASTM 20%- 10% TEMP. = 60 °F
ASTM 10% TO 90% SLOPE = 2.8 °F/%
Lines of Constant API Gravity
Lines of Constant ASTM 10% to 90% Slope

FIGURE 12.15—Example—Phase diagram construction for petroleum fractions.

FIGURE 12.14—Phase diagram construction chart.

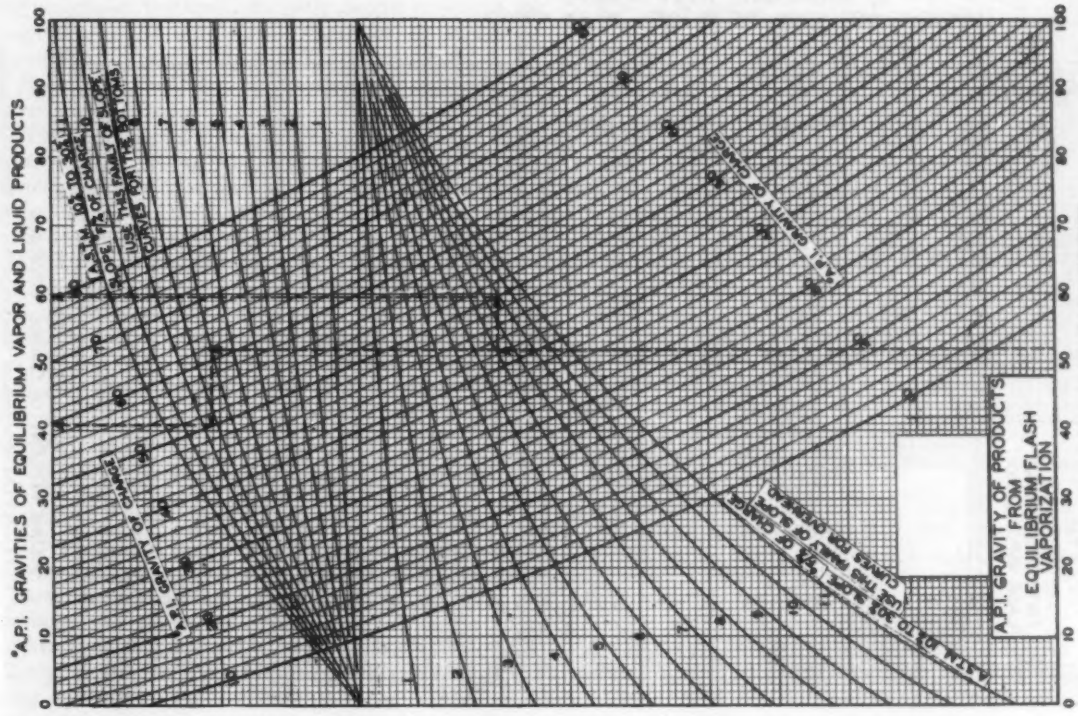
°A.P.I. GRAVITIES OF EQUILIBRIUM VAPOR AND LIQUID PRODUCTS
VOLUME PERCENT OF CHARGE VAPORIZED
A.P.I. GRAVITY OF PRODUCTS FROM EQUILIBRIUM FLASH VAPORIZATION
A.P.I. GRAVITY OF CHARGE
ASTM 10 TO 30% SLOPE, °F. OF CHARGE
USE THIS FAMILY OF SLOPE CURVES FOR THESE BOTTOMS

FIGURE 12.16—API gravity of products from equilibrium flash vaporization.

atmospheric pressure conditions. This requires a different construction chart. Such a chart is discussed in the next installment.

Following are the detailed steps of the solution of the example shown on Figure 12.15. The example is solved using the simpler three-parameter focal point correlation included in Figure 12.14.

Example 1: Construct a phase diagram for a stabilized gasoline with the following properties:

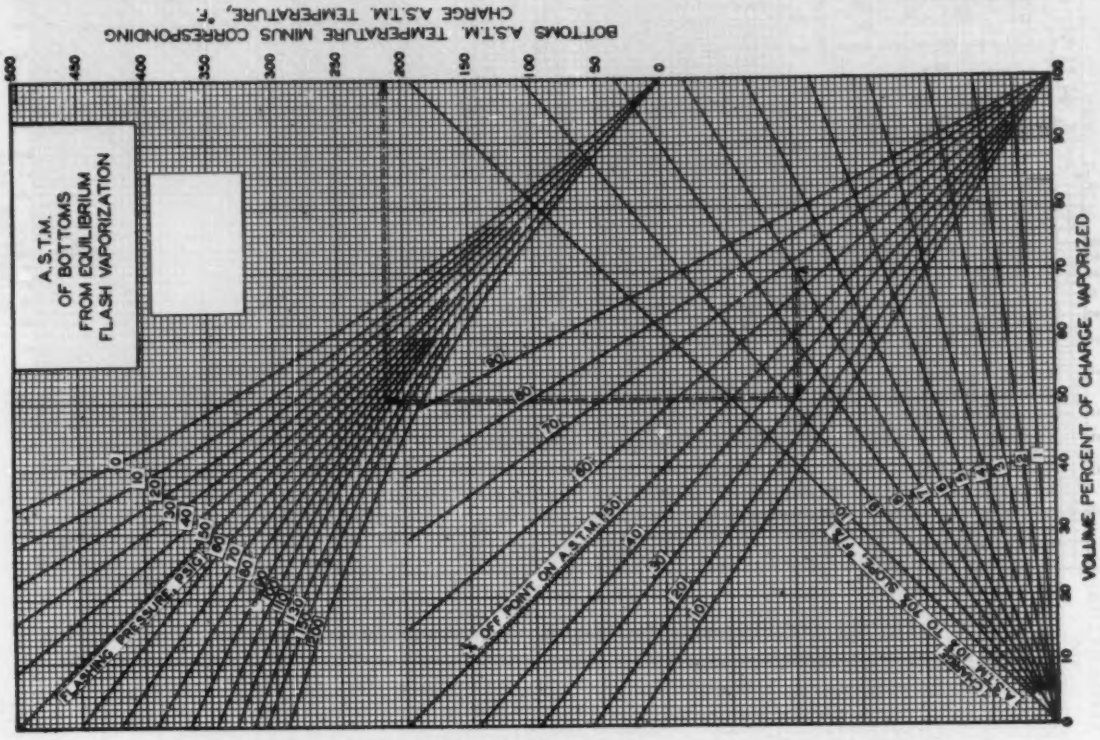
BOTTOMS A.S.T.M. TEMPERATURE MINUS CORRESPONDING CHARGE A.S.T.M. TEMPERATURE, °F.
A.S.T.M. OF BOTTOMS FROM EQUILIBRIUM FLASH VAPORIZATION
FLASHING PRESSURE, PSIA
% OFF POINT ON A.S.T.M. (D-86)
A.S.T.M. SLOPE, °F. PER VOL. % OF CHARGE
VOLUME PERCENT OF CHARGE VAPORIZED

FIGURE 12.18—ASTM of bottoms from equilibrium flash vaporization.

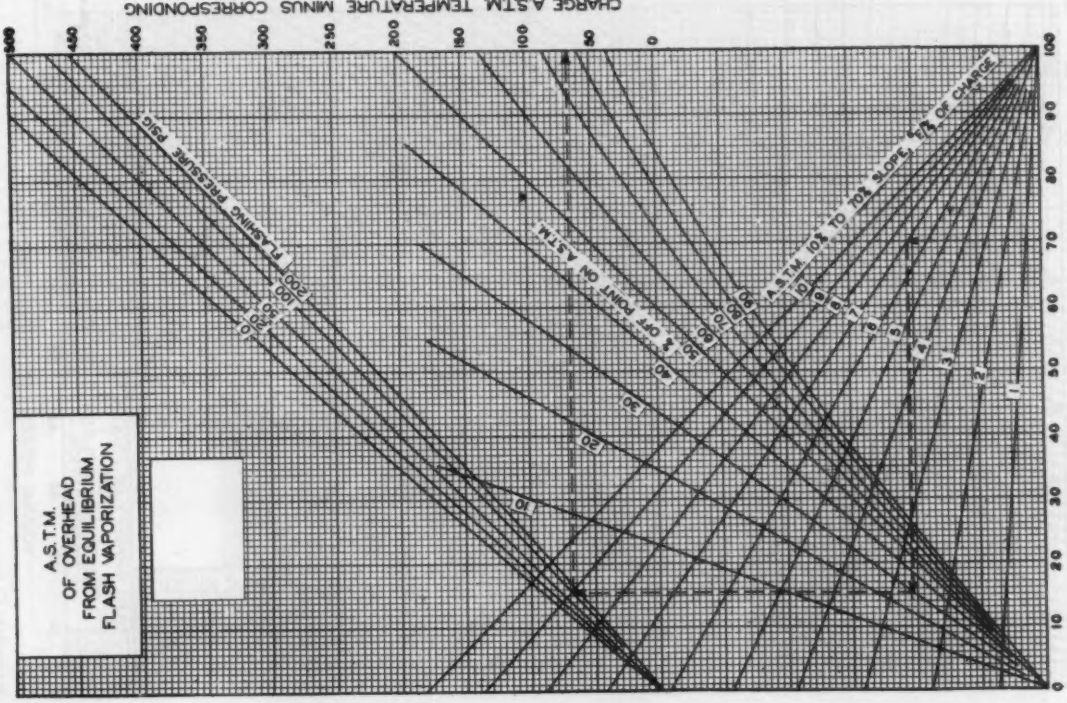
CHARGE A.S.T.M. TEMPERATURE MINUS CORRESPONDING OVERHEAD A.S.T.M. TEMPERATURE, °F.
A.S.T.M. OF OVERHEAD FROM EQUILIBRIUM FLASH VAPORIZATION
FLASHING PRESSURE, PSIA
% OFF POINT ON A.S.T.M.
A.S.T.M. SLOPE, °F. PER VOL. % OF CHARGE
VOLUME PERCENT OF CHARGE VAPORIZED

FIGURE 12.17—ASTM of overhead from equilibrium flash vaporization.

	ASTM DISTILLATION (CORRECTED FOR LOSS)										
	IBP	10%	20%	30%	40%	50%	60%	70%	80%	90%	EP
°API 61.6	63°F	117	156	186	213	239	262	287	312	342	400°F

Solution: The calculations in determining the atmospheric EFV curve are tabulated in the upper left-hand corner of Figure 12.15.

Step 1—The ASTM distillation is tabulated in Column 2.

Step 2—The temperature differences between the indicated points on the ASTM curve are shown in Column 3.

Step 3—From the ASTM 30-10% temperature difference of 69°F and the ASTM 50% point of 239°F, the EFV 50% point is found from Figure 12.8 as 216°F and is entered in Column 5.

Step 4—The EFV curve temperature differences for the various segments corresponding to the ASTM temperature differences are read from Figure 12.9 and tabulated in Column 4.

Step 5—The EFV curve points in Column 5 are determined by subtracting and adding to the EFV 50% point the differences in Column 4.

Step 6—Enter Figure 12.14 with the ASTM VABP at the lower right corner, follow dashed lines and arrows to locate the focal point.

Step 7—Locate the temperatures corresponding to the various EFV percentage on the atmospheric pressure line.

Step 8—Draw straight lines from the points located in Step 7 to the focal point and the phase diagram results.

Properties of Vapor and Liquid from EFV. The previous correlations permitted predicting the P-T-X (pressure-temperature-percent vaporized) relationships for petroleum fractions. In most design problems the properties of the equilibrium vapor or liquid are required in addition to the P-T-X information.

From experimental data, three empirical correlations have been developed[11] for predicting the gravities and ASTM distillations of the equilibrium vapor and liquid from flash vaporization. These correlations are presented as Figures 12.16, 12.17, and 12.18. In using these charts, the fact that they are strictly empirical with no theoretical basis should be remembered.

Figure 12.16 may be used to estimate the API gravities of the vapor and liquid products from the EFV. The ASTM 10%-30% slope of the charge, in addition to the gravity of the charge and the percent flashed, are the variables used. The vaporization pressure and temperature do not enter into this correlation because the product gravities are assumed to be independent of the vaporization conditions.

Figures 12.17 and 12.18 are used for estimating the ASTM distillations of the overhead and bottoms products from EFV's. The readings from these charts are differences between the corresponding points on the product and charge distillation curves. In these correlations the 10% to 70% ASTM slopes are used, and flashing pressure is a variable.

Example 2: Find the ASTM distillation and gravity of the vapor and liquid resulting from a flash at 100 psig and 520°F of a 43.2° API stock having an ASTM distillation as follows: 0% = 187°F, 10% = 248°F, 30% = 322°F, 50% = 374°F, 70% = 424°F, 90% = 486°F, and 100% = 520°F. from a phase diagram, it is determined that this corresponds to 43.5% of the charge vaporized.

Solution

Percent	ASTM DISTILLATION, t°F		
	Charge	Vapor	Liquid
10	248	223	308
30	322	272	370
50	374	307	411
70	424	347	452
90	486	399	504
°API	43.2	48.5	38.5

Step 1—From ASTM of charge find slopes

$$\text{ASTM 10\% to 70\% Slope} = \frac{424\text{-}248}{60} = 2.9°\text{F}/\%$$

$$\text{ASTM 10\% to 30\% Slope} = \frac{322\text{-}248}{20} = 3.7°\text{F}/\%$$

Step 2—From Figure 12.16, find the gravities of the vapor and liquid by following dashed lines and arrows similar to those shown.

Step 3—From Figure 12.17, determine the ASTM distillation of the vapor by following dashed lines and arrows similar to those shown.

Step 4—From Figure 12.18, determine the ASTM distillation of the liquid by following dashed lines and arrows similar to those shown.

These results are given in the above tabulations.

FIGURE 12.18—ASTM of bottoms from equilibrium flash vaporization.

FIGURE 12.17—ASTM of overhead from equilibrium flash vaporization.

VOLUME PERCENT OF CHARGE VAPORIZED

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TO BE CONTINUED

Part 2 – Piping and Valves

Operator's Handbook for Gasoline Plants

Prepared by plant superintendents and operating staff, this handbook is written so that the new and experienced operator can understand the most important equipment and operations of natural gasoline plants

Manufacturing Department, Bay Petroleum Company, A Division of Tennessee Gas Transmission Co., Houston

PIPING AND VALVES are two major kinds of equipment an operator should know well.

PIPING

Just as veins and arteries are vital to the life of human beings, so is piping indispensable to the life of a natural gasoline plant. Piping has become the most economical method of fluid transportation. Initial cost, working pressure, maintenance requirements, and life expectancy are factors that must be studied in the design of gasoline plant piping.

Pipe Sizes. All sizes of pipes through 12 inch are specified by the nominal inside diameter. The actual outside diameter for this range of pipe is always larger than the nominal size while the actual inside diameter varies according to the wall thickness of the pipe specified. The nominal pipe diameter and the actual outside diameter for pipe larger than 12 inch are the same. Extra strong and double extra strong pipe are made for use at high pressure. The extra thickness is obtained by reducing the inside diameter, the outside diameter remaining constant for a given nominal diameter pipe. Pipe is usually manufactured in joints from 20 to 22 feet long.

Pipe Materials. Cast-iron pipe is cheaply made and is used for air, water, exhaust steam, condensate, drain, lube oil, and fuel gas lines when in low pressure service. Pressures higher than 125 psi generally require carbon steel pipe. Special materials like stainless steel, stoneware, rubber, wood, lead, plastic and glass are often found necessary for corrosive service.

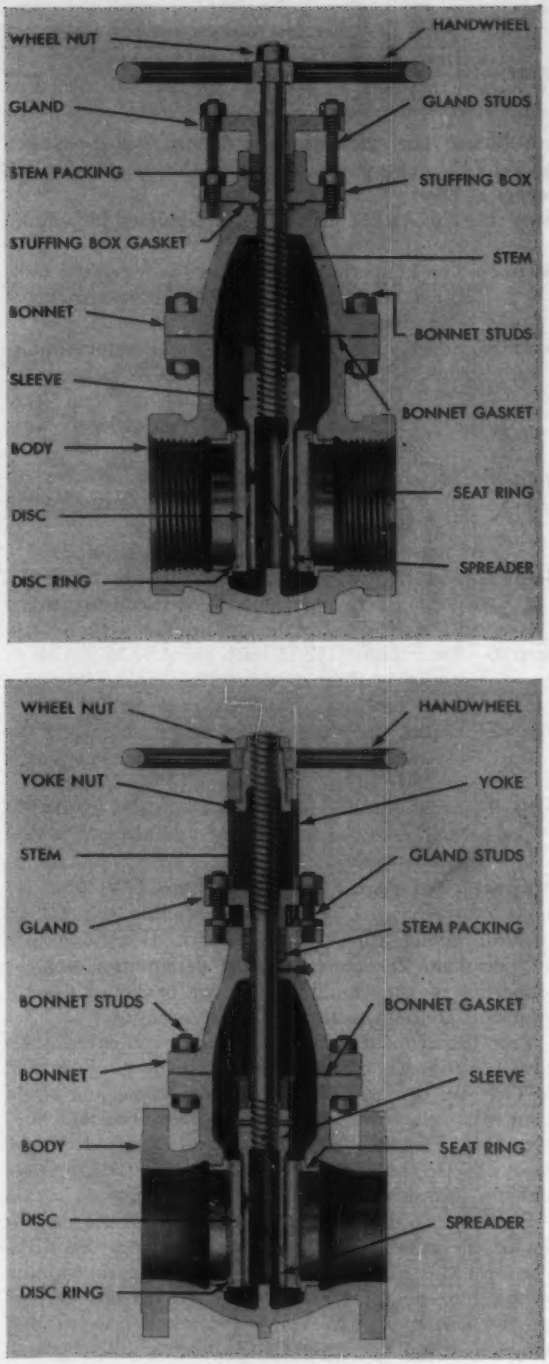


FIGURE 7—Gate valves: Non-rising stem (top), outside screw and yoke (bottom).

Working Pressures. The American Standards Association (ASA) rates different types of pipe for pressure service. Their rating is based on the maximum stresses allowed in the pipe. These stresses are caused by the temperature and pressure the pipe is subjected to. For example, a 300# ASA rated pipe could be used for either a service of 300 psi at 800°F or a service of 600 psi at 100° F. Substantial savings can be safely realized

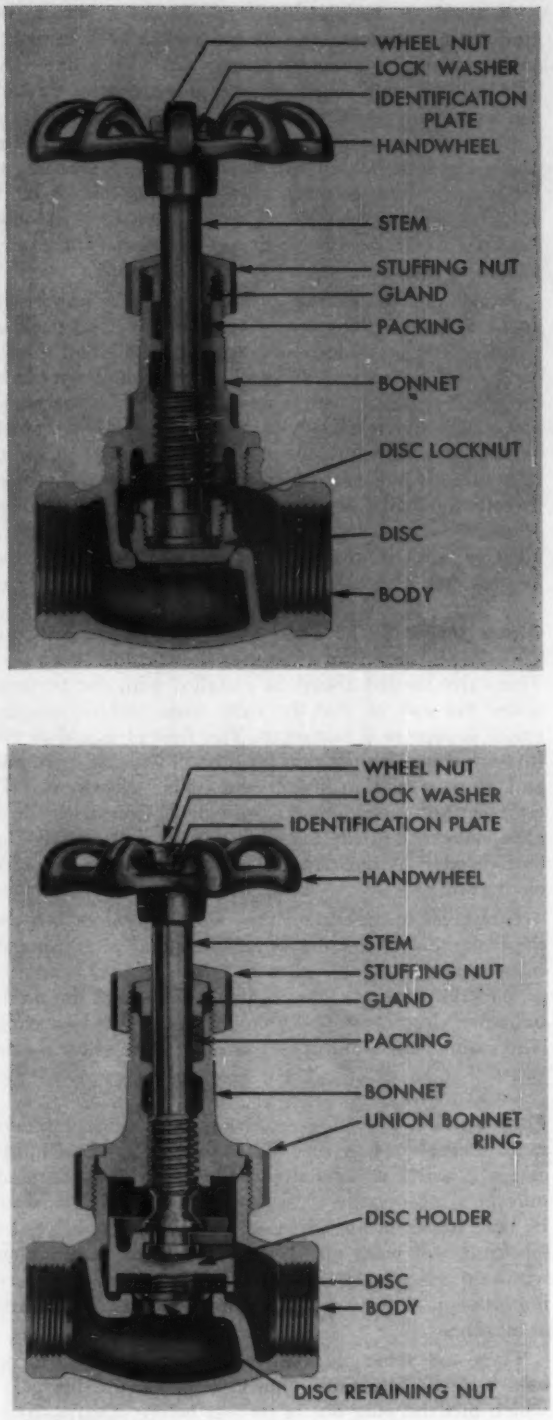


FIGURE 8—Globe valves: Standard screwed bonnet valve (top), union bonnet valve with renewable disc (bottom).

in piping selection if the variation of pressure with temperature principle is remembered.

Fittings. Pipe fittings of steel, brass, iron, and special metals are made standard or extra heavy, flanged or screwed. Small pipe (1½-inch or less) is generally joined with screw fittings. This type of joint is the most common and is suitable for low and moderate pressures at the lower temperatures.

Flanged joints and fittings are widely used because they facilitate erection and dismantling and are readily joined to fittings and valves. There are many methods for attaching the flanges, the three main classes being screwed, lapped, and welded.

To designate the size of fittings, a standard procedure has been adopted. Run openings are designated first; side openings last. Thus, a 4 x 3 tee would have 4-inch diameter run openings and a 3-inch side opening.

Installation. All piping should be so arranged as to effect the shortest possible runs consistent with good design and to require the minimum number of bends and fittings. The modern day trend is to install most process piping above ground and support it with steel beams anchored in concrete. Piping should be arranged so all valves and operational instruments are accessible from the ground or platforms. All lines should be well supported and anchored to prevent vibration or strain on any piece of plant equipment. Ease of inspection and repair is another advantage of this type of installation.

Water, fuel, sewage and drain piping are usually the only lines that are installed underground. Placing these lines underground will prevent their bursting during winter operations when the ambient temperature falls below the freezing point of the piped fluid. To protect these lines from corrosion, a cathodic protection system is usually found economically and operationally necessary.

Insulation. Insulation is necessary to prevent the flow of heat from the pipe to surroundings or to prevent the flow of heat from the outside air into the piped fluid. Accordingly, the study of insulation is broken down into two fields—hot insulation and cold insulation.

Good insulating materials are chosen for their low heat conducting properties. This property has been measured for many materials and given the name of thermal conductivity coefficient. This coefficient therefore is an indication of the comparative insulating qualities of the various materials. The insulating properties of the more common materials used are shown in the following table:

COLD INSULATION

Material	Thermal Conductivity BTU/Hr Ft²°F/in.	Description
Balsa Wood	0.35	Light and soft across grain
Wood Shavings	0.42	Various
Sawdust	0.40	Various
Ground Cork	0.33	Granulated 1/16 to ⅛ In.
Rock Wool	0.30	Firmly packed

HOT INSULATION

Rock Wool	0.65	Firmly packed
85% Magnesia	0.60	At 600 °F
Asbestos	0.55	Multiple paper and sponge
Missouri Fire Clay Brick	8.7	At 1100 °F
Diatomaceous Earth	0.74	Molded

VALVES

For any piping system to perform successfully the proper selection and location of the valves that control

and regulate the piped fluids must be made. Valves should be so located that their maintenance and operation may be performed without interrupting the process flow. The majority of the valves used are manually operated and classified as:

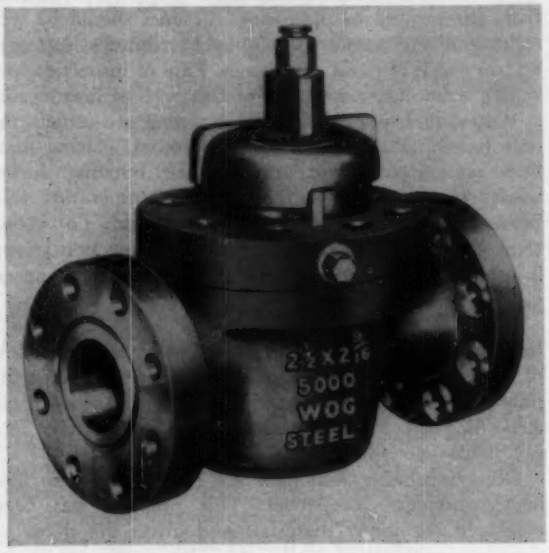
Gate
Globe
Plug

The automatic type valve is used in the control system and controls the process variables without any human assistance.

Gate Valves. The gate valve is just what it implies—a gate in the pipe line. It is usually full opening; that is, when the valve is wide open, the opening is the same size as the inside diameter of the pipe line. This valve should not be used as a throttling valve, but used either wide open or completely closed. Figure 8 shows two kinds of gate valves. As you can see, in both cases the valve opening is about the same size as the line. The gate valve is used whenever the pressure drop through the valve is of importance and no regulation is desired.

Gate valves are normally used on water lines at the pump, on both suction and discharge sides. Another use for gate valves is as a block valve in any line. A block valve means a valve that is very seldom used. A good example would be on oil lines to heaters. There they would be used only in case of a tube rupture.

Proper maintenance of gate valves is very important, and certain practices should be followed. The packing gland should be pulled down to allow the gland to seat itself correctly against the packing. If this is not done, the gland will leak with a resultant strain on the gland when the valve is opened or closed. *Never* use a wrench to close this valve because this distorts the seat, causing it to slip. If the valve is a rising stem type, the stem threads should be kept free from paint, dirt, and dust. If a valve is installed below the ground it should have a guard around it to keep the dirt away. It should also be protected against corrosion.



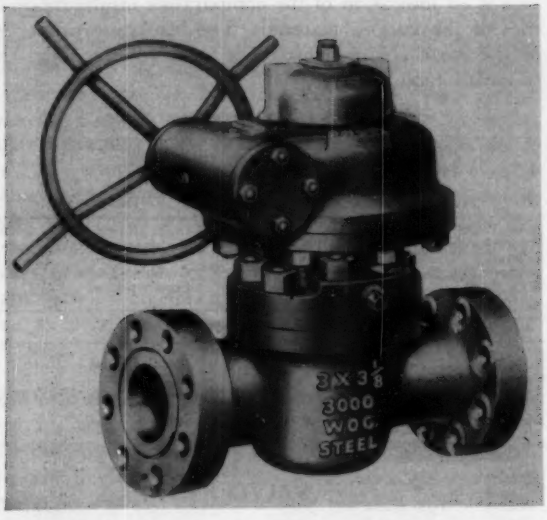


FIGURE 9—Plug valves: Wrench operated (top), gear operated (bottom).

Globe Valves. The globe valve is used primarily for throttling or to control a specified flow through the valve. This valve should always be installed with the pressure under the seat, so that the valve stem packing maintenance is kept to a minimum. The flow of liquid or gas through this valve contacts all sides of the disc or needle and thus results in even wear. This allows a leak-tight shut-off even on a worn valve. Conversely, if a gate valve was used, the flow would contact only the bottom edge of the disc, cause uneven wear, and leak on shut-off.

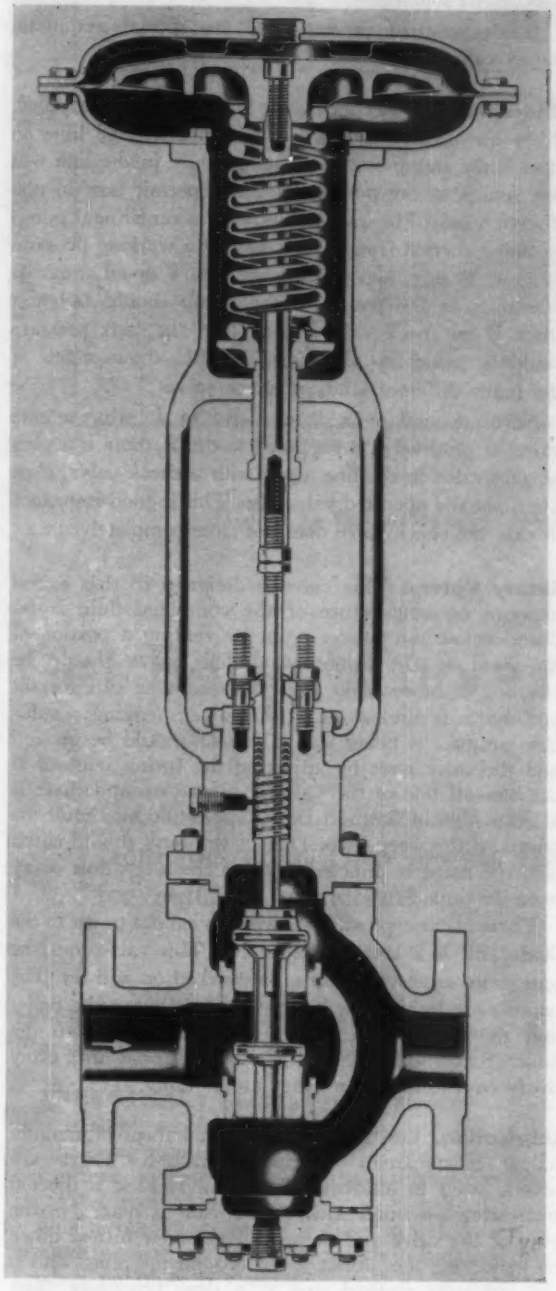
Globe valves are called slow opening valves because they take several turns to open. Globe valves are similar in appearance to gate valves but they are used primarily as throttling valves. They control the flow of the product when close control by a motor valve is not necessary. The maintenance and upkeep are the same as for a gate valve.

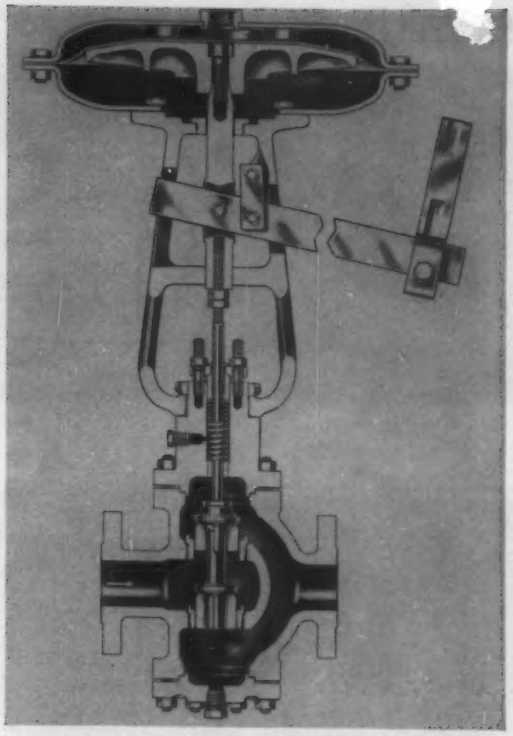
Plug Valves. The plug valve is used in gasoline plants more than any other type. With proper care and lubrication it will last indefinitely. This valve is to be used only in a full open or closed position and should never be used for throttling. If used as a throttling valve the lubricant will wash off. When this occurs, a dry plug works on a dry body and the valve soon leaks. It is very important that this type of valve be properly lubricated at all times.

There are some plug valves that are designed to be used without lubricant. One example is the lift plug, which lifts the plug out of its seat before it turns. This prevents metal contact while the plug is turning.

One other type of plug valve which is neither a lubricated nor rising plug is called a stop cock. These valves are usually used on lines when it is not necessary to operate the valve often.

Control Valves. Control systems use special valves which are automatically rather than manually operated. These valves may be used to control flow, pressure, or





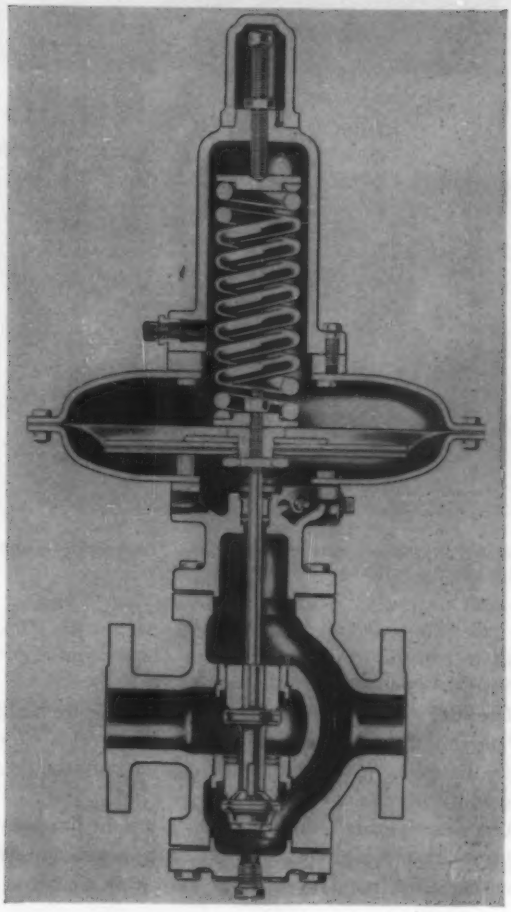


FIGURE 10—Control valves and regulators: Spring loaded (above), weight loaded (top right) and direct mounted diaphragm (right).

temperature. They may also be classified according to decreasing complexity:

1. Controllers or control valves
2. Pilot-operated regulators
3. Self-actuated regulators

These valves may be pilot, weight or spring operated. Pilot operated valves are operated by admitting air

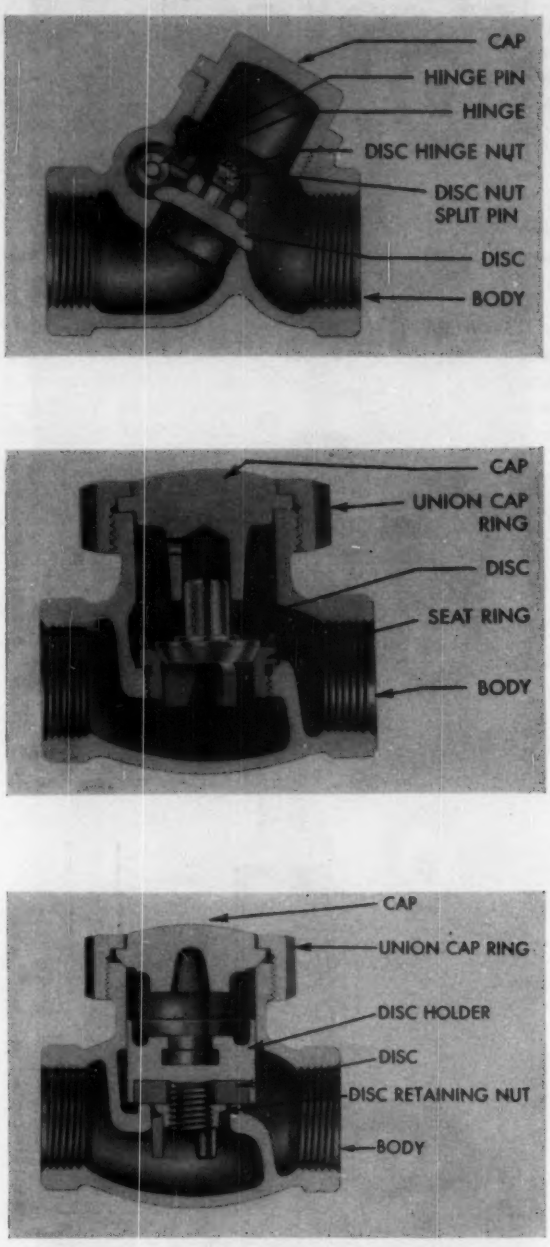


FIGURE 11—Check valves: Swing (top), horizontal (center) and horizontal with renewable disc (bottom).

from a control instrument to the diaphragm of the valve, thus opening or closing the valve.

The spring-operated valve is opened by pressure building up on the bottom of the valve. The valve closes when the spring pressure becomes greater than the pressure on the bottom of the valve.

The weight-loaded valve employs a weight instead of a spring. The spring type, however, is the most common.

Self-actuated regulators, either spring or weight operated, can be repaired in the field or shop most of the time. The other valves can be repaired only by trained instrument repairmen.

Besides control valves, there are special automatic valves called check valves and safety valves.

Check Valves. A check valve is a form of safety valve. They are usually installed in pump discharge lines so that if the pump stops, all the pressure in the line will not return to the pump. They will permit flow in one direction only. For instance, suppose a centrifugal pump is taking suction from a tank having a working pressure of only 50 psig, and discharging into a de-ethanizer at 500 psig. If the power to the pump should fail and there is no check valve in the line, the tank pressure could be raised to 500 psig. Figure 11 shows a few of the many different kinds of check valves.

Never depend on a check valve to do what a gate valve or plug valve is supposed to do. If there is a plug or gate valve in the line along with a check valve, close the manually operated valve also. This is good insurance in case the check valve does not close completely.

Safety Valves. This valve is designed so that excess pressure or temperature of the contained fluid is reduced below the danger point by venting a portion of the fluid to the atmosphere. This valve should be checked often to make sure the setting is still correct and that it is not leaking. If the valve is leaking, a valuable product is being lost. The seat should be ground and the valve reset by adjusting the spring tension. If the blowoff line of the valve is turned up and there is a weep hole in the bottom, a nipple and ell should be added to the weep hole. Then if the tank should catch fire, the flame is directed through the weep hole away from the tank.

There is one type safety valve that cannot be set in the field. This is a boiler safety valve. This valve must be sent to an approved shop to be worked on and set. The boiler code forbids any kind of valve between the boiler and the safety valve. It must fasten directly on the boiler. Safety valves should be checked about once every thirty days to make sure they are working.

Lubrication. Lubrication is a special form of maintenance that cannot be overemphasized. There are several ways to lubricate a plug valve. First is the old time screw—a small stick of lubricant is placed in the plug of the valve and then the jack screw turned down on it, forcing the lubricant out around the plug. This is the old style method and is a slow procedure. The method most widely used is the grease gun method. In place of the jack screw, the plug valve has a button head fitting screwed in the top. A grease gun filled with the proper lubricant is fastened on the fitting and the lubricant pumped into the valve. One method uses the button head fitting with an air operated gun to force the lubricant into the valve. The important thing is to see that the valves receive the proper amount of lubrication at regular intervals. This is preventive maintenance and will prolong the life of the valve.

(To be Continued; Part I was in May issue)

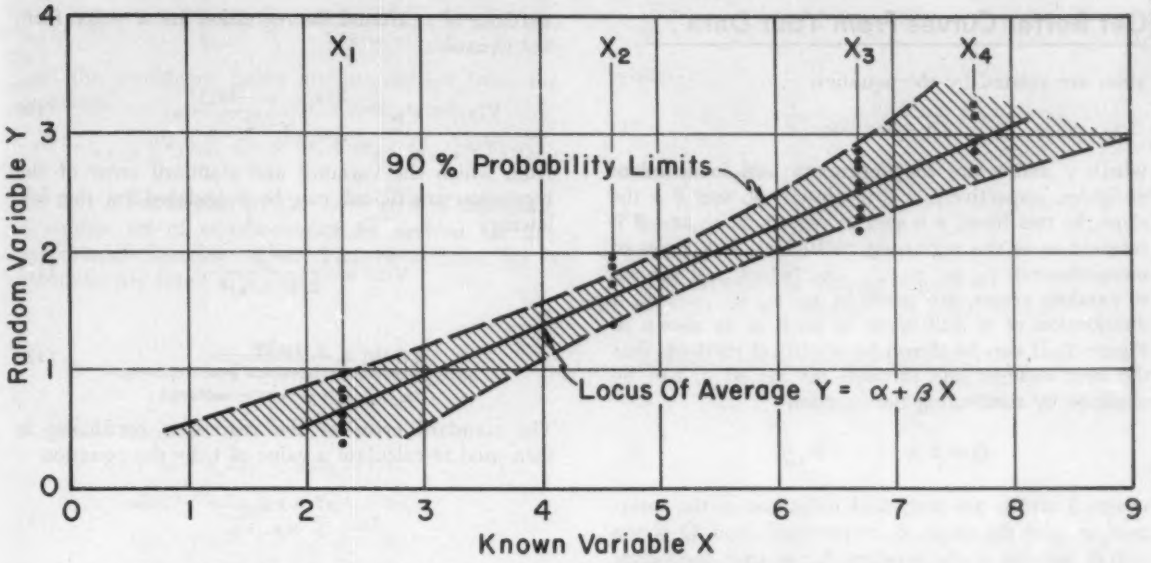


FIGURE 1—This method helps you find the best line which will correlate your data.

Get Better Curves From Your Data

Use the method of least squares to get better correlations from your data. Then you can also tell how good they are for making predictions

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THE PRIMARY GOAL of most experimental work is to establish relationships between the variables in the system being studied. It is usually the hope of the experimenter to express these relationships as mathematical curves.

One technique for fitting a curve to test data is to use the method of least squares. Unfortunately, this method normally is resorted to only if the data are badly scattered and can not be treated in any other way. However, the method is a powerful analytical tool that can yield, in addition to an empirical curve, the precision of the experimental data, the confidence limits of values taken from the derived curves, and the degree of confidence that can be placed upon data selected from the curve when it is used for the prediction of new experimental results.[1,2]

This article will review the development of techniques of least-squares curve fitting, and demonstrate how the information obtained may be used for an error analysis of the experimental system. Specific examples of the application of these techniques to data obtained from dehydrogenative reforming experiments will be given.

WE USE THIS METHOD

Although the methods of least-squares are covered in a number of applied mathematics texts, the coverage is usually limited to the mechanical operations involved in evaluating the curve constants. Our development, however, will only review briefly the mechanical operations, and then give the expressions necessary for a complete error analysis of a derived curve without regard for mathematical rigor. Since such an undertaking requires some familiarity with statistical terminology, a brief section on basic statistical definitions used in conjunction with the normal-distribution curve is given in an accompanying box.

To Get a Straight Line. Let there exist an experimental system such that the true values of the vari-

ables are related by the equation

$$y = \alpha + \beta x, \tag{1}$$

where y and x are the dependent and independent variables, respectively, α is the intercept, and β is the slope. In this form, y is said to regress on x, and β is referred to as the regression coefficient. If a series of measurements $y_1, y_2, y_3, \ldots y_i$, which are subject to random errors, are made at $x_1, x_2, x_3, \ldots x_i$, a distribution of y_i will occur at each x_i as shown in Figure 1. It can be shown by statistical methods that the best straight line through the set of y_i can be obtained by minimizing the function

$$Q = \Sigma (y_i - a - bx_i)^2, \tag{2}$$

where a and b are statistical estimates of the intercept, α, and the slope, β, respectively, and Q is the sum of squares of the residues, R_i, of each individual equation

$$R_i = y_i - a - bx_i \tag{3}$$

Equation 2 is minimized by setting the derivatives $\frac{\partial Q}{\partial a}$ and $\frac{\partial Q}{\partial b}$ equal to zero, and solving the resulting regression equations,

$$na + b\Sigma x_i = \Sigma y_i, \tag{4}$$

and

$$a\Sigma x_i + b\Sigma x_i^2 = \Sigma x_i y_i, \tag{5}$$

for a and b. Such a solution leads to

$$a = \bar{y} - b\bar{x}, \tag{6}$$

and

$$b = \frac{\Sigma (x_i - \bar{x})(y_i - \bar{y})}{\Sigma (x_i - \bar{x})^2}, \tag{7}$$

where

$$\bar{x} = \frac{\Sigma x_i}{n}, \tag{8}$$

$$\bar{y} = \frac{\Sigma y_i}{n}, \tag{9}$$

and n is the total number of experimental points.

Since the nature of the techniques requires that a real solution for a and b exist, it is necessary to test for the statistical significance of the regression line, which is done by comparing the calculated value of the regression coefficient with zero. If the regression coefficient is significantly different than zero, it can be concluded that there is a finite change in y_i for a finite change in x_i. A lack of significance, however, would indicate that either no regression line exists (y = constant), or that the variations due to experimental error are large enough to mask the variations due to changes in the independent variable x.

To perform the test, it is necessary to calculate the variance of y_i around the regression line $a + bx_i$ from the equation

$$V(y_i) = s^2_{yx} = \frac{\Sigma (y_i - a - bx_i)^2}{n - 2}, \tag{10}$$

from which the variance and standard error of the regression coefficient can be calculated by the following:

$$V(b) = \frac{s^2_{yx}}{\Sigma (x_i - \bar{x})^2}, \tag{11}$$

$$\text{S.E.}(b) = \frac{s_{yx}}{\sqrt{\Sigma (x_i - \bar{x})^2}}, \tag{12}$$

The standard error of the regression coefficient is then used to calculate a value of t, by the equation

$$t_{calc.} = \frac{|\, b \,|}{\text{S.E.}(b)} \tag{13}$$

which is compared with table values of t for n–2 degrees of freedom. If at some probability level q in the table, the calculated value of t is greater than the table value of t, it can be concluded that the regression coefficient is significant, and that this conclusion has q chances in 100 of being wrong.

Once it has been established that b is significant at some level q, it can be shown that the true value of the regression coefficient, β, is related to the estimate, b, in such a manner that

$$b - [t_{q,n-2}]\,[\text{S.E.}(b)] < \beta < b + [t_{q,n-2}]\,[\text{S.E.}(b)] \tag{14}$$

The precision of the experimental measurements expressed as the confidence limits of any value y_o on the curve can then be calculated from the following set of equations:

$$V(y_o) = s^2_{yx}\left[\frac{1}{n} + \frac{(x_o - \bar{x})^2}{\Sigma (x_i - \bar{x})^2}\right], \tag{15}$$

$$\text{S.E.}(y_o) = \sqrt{V(y_o)}, \tag{16}$$

and

$$y_o - [t_{q,n-2}]\,[\text{S.E.}(y_o)] < \alpha + \beta x_o < y_o + [t_{q,n-2}]\,[\text{S.E.}(y_o)] \tag{17}$$

Although equation 17 is valid for determining the confidence limits of this single set of experimental data, it cannot be used without modification for the prediction of new data for the same experimental system. These modifications become necessary when it is realized that the single set of data is one sample from the true system, and that a predicted value of y_i at a value x_i would be equivalent to a second or third sampling of a population, and would be subject not only to the variance of y_i about the curve, but also to the variance of the most probable values of y_i around the mean of the most probable values of y_i. Accordingly, the variance for a predicted value, y^p_o, takes the form

$$V(y^p_o) = s^2_{yx}\left[1 + \frac{1}{n} + \frac{(x_o - \bar{x})^2}{\Sigma(x_i - \bar{x})^2}\right], \qquad (18)$$

and the confidence limits are determined from the equation

$$y^p_o - t_{q,n-2}\sqrt{V(y_{po})} < \alpha + \beta x_o < y^p_o + t_{q,n-2}\sqrt{V(y^p_o)}. \qquad (19)$$

To Get a Parabola. By the same type of reasoning, a similar set of equations can be derived for any polynomial function of x. The equations for a parabola are listed in Table 1.

TABLE 1
Regression and Variance Equations for the Equation $y = \alpha + \beta_1 x + \beta_2 x^2$

Regression Equation:

$$na + b_1\Sigma x_i + b_2\Sigma x_i^2 = \Sigma y_i$$

$$a\Sigma x_i + b_1\Sigma x_i^2 + b_2\Sigma x_i^3 = \Sigma x_i y_i$$

$$a\Sigma x_i^2 + b_1\Sigma x_i^3 + b_2\Sigma x_i^4 = \Sigma x_i^2 y_i$$

Regression Coefficients:

$$b_1 = \frac{S(xy)\,S(x^4) - S(x^3)\,S(x^2y)}{S(x^2)\,S(x^4) - [S(x^3)]^2}$$

$$b_2 = \frac{S(x^2)\,S(x^2y) - S(xy)\,S(x^3)}{S(x^2)\,S(x^4) - [S(x^3)]^2}$$

$$a = \bar{y} - b_1\bar{x} - b_2\bar{x}^2$$

$$S(x^2) = \Sigma(x_i - \bar{x})^2$$

$$S(x^3) = \Sigma(x_i - \bar{x})\,(x_i^2 - \bar{x}^2)$$

$$S(x^4) = \Sigma(x_i^2 - \bar{x}^2)^2$$

$$S(xy) = \Sigma(x_i - \bar{x})\,(x_i - \bar{y})$$

$$S(x^2y) = \Sigma(x_i^2 - \bar{x}^2)\,(y_i - \bar{y})$$

Total Variance of y_i Around Curve:

$$V(y_i) = s^2_{yx^2} = \frac{\Sigma(y_i - a - b_1x_i - b_2x_i^2)^2}{n-3}$$

Standard Error of Regression Coefficients:

$$\text{S.E. } (b_1) = \sqrt{\frac{s^2_{yx^2}\,S(x^4)}{S(x^2)\,S(x^4) - [S(x^3)]^2}} = s_{yx^2}\sqrt{C_{11}}$$

$$\text{S.E. } (b_2) = \sqrt{\frac{s^2_{yx^2}\,S(x^2)}{S(x^2)\,S(x^4) - [S(x^3)]^2}} = s_{yx^2}\sqrt{C_{22}}$$

Significance of Regression Coefficients:

$$t_{b_1} = \frac{|\,b_1\,|}{\text{S.E. } (b_1)}$$

$$t_{b_2} = \frac{|\,b_2\,|}{\text{S.E. } (b_2)}$$

Confidence Limits of Regression Coefficients:

$$b_1 - (t_{q,n-3})\,(s_{yx^2})\sqrt{C_{11}} < \beta_1 < b_1 + (t_{q,n-3})\,(s_{yx^2})\sqrt{C_{11}}$$

$$b_2 - (t_{q,n-3})\,(s_{yx^2})\sqrt{C_{22}} < \beta_2 < b_2 + (t_{q,n-3})\,(s_{yx^2})\sqrt{C_{22}}$$

Variance of Any Point y_o at x_o:

$$V(y_o) = s^2_{yx^2}\left[\frac{1}{n} + (x_o - \bar{x})\,C_{11} + (x_o^2 - \bar{x^2})^2\,C_{22} + 2\,(x_o - \bar{x})\,(x_o^2 - \bar{x^2})\,C_{12}\right]$$

where:

$$C_{12} = -\frac{S(x^3)}{S(x^2)\,S(x^4) - [S(x^3)]^2}$$

Confidence Limits of y_o for Any x_o:

$$y_o^p - t_{q,n-3}\sqrt{V(y_o^p)} < \alpha + \beta_1 x_o + \beta_2 x_o^2 < y_o^p + t_{q,n-3}\sqrt{V(y_o)}$$

Variance of Predicted Value of y_o at x_o:

$$V(y_o^p) = s^2_{yx^2}\,[1 + V(y_o)]$$

Confidence Limits of Predicted Value of y_o at x_o:

$$y_o^p - t_{q,n-3}\sqrt{V(y_o^p)} < \alpha + \beta_1 x_o + \beta_2 x_o^2 < y_o^p + t_{q,n-3}\sqrt{V(y_o^p)}$$

Normal test procedure for a parabola is to evaluate the constants b_1 and b_2 and test for the significance of b_2. If this quadratic coefficient appears to be insignificantly different from zero, the parabola is discarded, and a new linear coefficient is determined from the original data.

NOW TRY THESE EXAMPLES

Three examples of the use of the statistical techniques are given here. All data were selected from real sets of experimental points obtained from studies of a catalytic dehydrogenative petroleum-reforming process in bench-scale isothermal equipment. In every instance, constants were subtracted from each set of data to make the arithmetical computations less tedious.

Establishing a Yield-Octane Curve. A total of 142 datum points was collected for the purpose of determining a standard yield-octane curve. In addition to a standard curve, it was necessary to determine the precision of the derived curve in terms of the single set of data used, and to estimate the limits of predictability of the derived curve for use in the evaluation of yields of new catalyst preparation.

The results of the statistical calculations are summarized in Table 2. Since b_2 was significant at the 99.5 percent ($q = 0.5$) probability level, it was concluded that the data were described best by a curve that included a quadratic coefficient.

Confidence limits of the curve are also summarized in Table 2 for the 75 percent ($q = 25$) and 95 percent ($q = 5.0$) probability levels. It was concluded that the yield values obtained from the derived curve were probably in error not more than ± 0.3 percent (absolute) at the 95 percent probability level, and less than that for lower probability levels.

The problem of confidence limits becomes somewhat more complex when this curve is used for the comparison of new catalyst preparations with those used to determine the standard curve. In quality control, it would be necessary to know whether the results

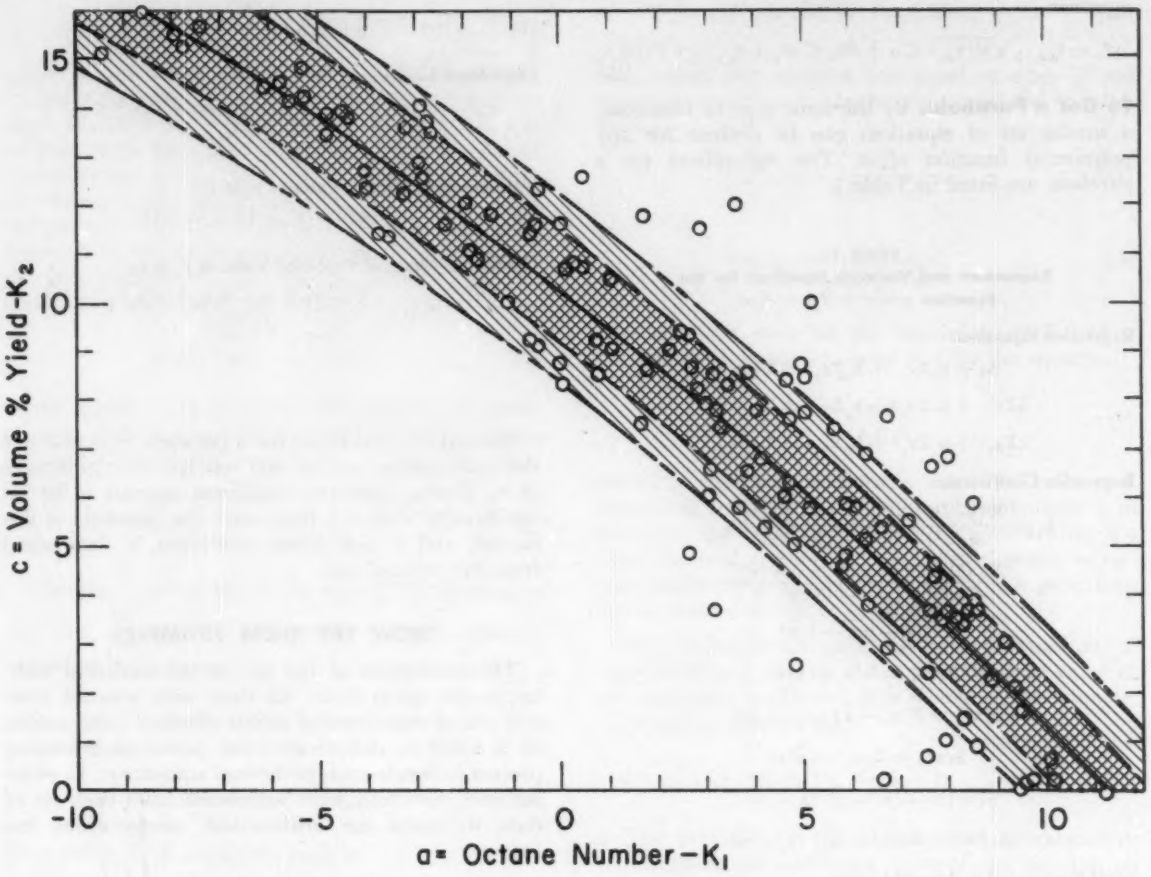

FIGURE 2—The relation between yield and product octane can be represented by the following equation: $c = 10.227 - 0.775\ a - 0.126\ a^2$. The narrow band represents the 75 percent probability limits while the wide band denotes 95 percent probability limits.

obtained with new batches of catalyst were different from the standard curve with a fair degree of certainty. In this instance the 95 percent predictability limits would be chosen, and all catalyst that differed in yield from the standard curve by more than ±2 percent (absolute) would be rejected. On the other hand, if new preparations were being tested, it would be necessary to differentiate between minor yield differences to avoid missing preparations that gave yields slightly different than those obtained from the standard curve. Accordingly, it would be more avdantageous in this instance to select the 75 percent limits (±1.1 percent absolute). These brackets, together with the derived curve, are shown in Figure 2. Twenty points were not plotted because the values were outside the range of the parameters of the figure.

What Part Does Particle Size Play? Two sets of data were available for this analysis, one set obtained with large catalyst particles comprising 11 points, and one set obtained with small particles comprising 31 points. The purpose of the analysis was to determine differences in octane levels that could be assigned to differences in particle size, as measured at constant temperature in the small-scale equipment used in these investigations.

The results of the statistical calculations are summarized in Tables 3 and 4. The analyses showed the quadratic contribution to the activity curve of the small-diameter particles was significant at the 95 percent ($q = 5$) but not at the 97.5 percent ($q = 2.5$) probability level; whereas the quadratic term for the larger pellets was not significant at the 95 percent level. It was assumed, therefore, from the limited data available, that both sets of data could be described best by straight lines. Accordingly, linear regression coefficients were calculated for each set of data. These curves together with the 95 percent confidence limits are plotted in Figure 3. Although the limits are calculated for $\Theta_o = 75$ in the table, the actual data do not apply beyond $\Theta_o = 50$ as shown in the figure.

As can be seen from the plots, there is a statistically

significant difference in activities between pellet sizes over the whole range of temperatures studied. It must also be concluded, however, both from these analyses and previous experience, that the best equation relating to octane level and temperature might not be a straight line, and attempts should be made to increase experimental precision or collect additional datum points.

Relating Octanes and Aromatics. The same sets of data used for calculating the temperature curves in the preceding section were used to correlate information concerning the aromatic content of liquid product and octane level. The purpose of these analyses was to determine whether or not octane level was achieved in the same manner for different-sized catalyst pellets.

The statistical calculations are summarized in Tables 5 and 6. These data, as in the previous section, indicate straight line relationships between aromatic content and octane level. From the tables, it can be seen that the 95 percent confidence limits of each curve overlap the curves themselves, indicating that no significant difference in aromatic contents of the liquid products at constant octane level is shown by these data. Accordingly, the information from both sets of data was combined and new regression coefficients were calculated as shown in Table 7.

The combined data indicated that the best curve describing the octane-aromatics relationship had a significant contribution from the quadratic term. This curve together with the 95 percent confidence limits have been plotted in Figure 4. It is interesting to note that although the quadratic term was not significant in the individual cases, it is highly significant in the combined cases. These results indicate that the completeness of a regression analysis depends, in part, on the number of datum points that are available for the analysis.

Many Applications Possible. Although the examples cited here are specific to one field, the general method can be applied to a variety of problems. It must be emphasized, however, that the technique requires supplementary technical judgment, and cannot be used as a substitute for good technical sense. Statistics, as a general rule, provides a systematic tool that can be used as an aid in making quantitative conclusions in experimental systems that might otherwise be rejected because of a lack of precise experimental control.

TABLE 2

Results of Statistical Calculations for Yield-Octane Curve

a = octane number $- K_1$ $\qquad$ c = yield $- K_2$

For curve: $c = \alpha + \beta_1 a + \beta_2 a^2$

Range of values: $a = -10$ to $+10$; $c = 0$ to 20

$n = 142$	$\Sigma ac = -2315.40$
$\Sigma a = 230.4$	$\Sigma a^2 c = 57479.813$
$\Sigma a^2 = 6103.98$	$S(a^2) = 5730.148$
$\Sigma a^3 = 4813.294$	$S(a^3) = 14717.216$

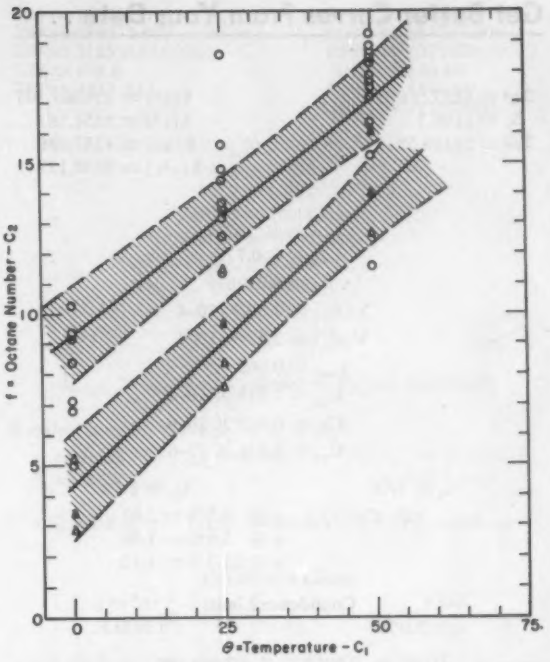

FIGURE 3—The effect of temperature on product octane depends on the size of catalyst used. The smaller catalyst (represented by circles) gives the following equation: $f_s = 9.36 + 0.155\ \Theta$, while the larger particles (represented by triangles) gives: $f_L = 4.265 + 0.190\ \Theta$. The 95 percent probability limits are shown by the shaded areas.

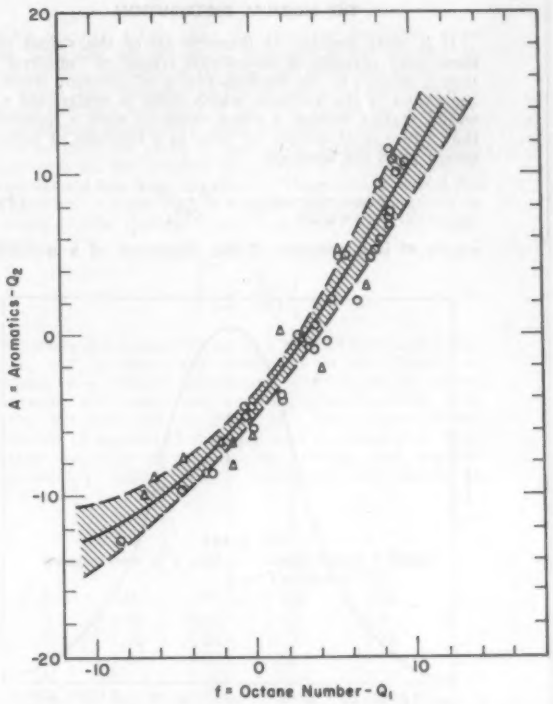

FIGURE 4—The product octane is influenced by the aromatic concentration. Therefore, the aromatic content can be estimated from the octane data by the following equation: $A = -4.166 + 1.18\,f + 0.036\,f^2$. The 95 percent probability limits are shown by the shaded area.

Get Better Curves From Your Data . . .

$\Sigma a^4 = 688772.0031$ $\quad S(a^4) = 426387.703$
$\Sigma c = 1196.7$ $\quad S(c^2) = 3354.383$
$\Sigma c^2 = 13439.53$ $\quad S(ac) = 4257.088$
$\quad S(a^2c) = 6038.137$

$\alpha = 10.227$
$\beta_1 = -0.775$
$\beta_2 = 0.0126$
$V(\beta_1) = 1.80 \times 10\text{–}4$
$V(\beta_2) = 2.42 \times 10\text{–}4$
$s_{cas^2} = 0.968$
$C_{11} = 1.915 \times 10\text{–}4$
$C_{12} = 6.610 \times 10\text{–}6$
$C_{22} = 2.573 \times 10\text{–}6$

$t_{\beta_1} = 57.8$ $\quad t_{\beta_2} = 8.14$

t @ 139 D.F.: q @ 0.5% = 2.81
q @ 5.0% = 1.96
q @ 25.0% = 1.15

Confidence Limits

q = 5.0% $\quad$ 139 D.F.

β_1: $-0.8013 < \beta_1 < -0.7487$

β_2: $-0.0157 < \beta_2 < -0.0094$

q = 5.0%

Confidence Limits

c_o at a_o:	Precision of c_o	Predicted Values
$a_o = 10$:	$1.08 < c_o < 1.62$	$-0.57 < c_o^p < 3.27$
$a_o = 1.6$:	$8.80 < c_o < 9.20$	$7.10 < c_o^p < 10.90$
$a_o = -10$:	$16.37 < c_o < 17.03$	$14.78 < c_o^p < 18.62$

q = 25.0%

Confidence Limits

c_o at a_o:	Precision of c_o	Predicted Values
$a_o = 10$:	$1.35 < c_o < 1.51$	$0.25 < c_o^p < 2.45$
$a_o = 1.6$:	$8.89 < c_o < 9.11$	$7.90 < c_o^p < 10.1$
$a_o = -10$:	$16.50 < c_o < 16.90$	$15.60 < c_o^p < 17.8$

TABLE 3
Small Particle Analysis: Temperature-Octane Curve

Θ = temperature — C_1 $\quad$ f_s = octane number — C_2

For curve: $f_s = \alpha_s + \beta_{1s}\Theta + \beta_{2s}\Theta^2$

n = 31 $\quad \Sigma f^2 = 6415.81$
$\Sigma\Theta = 850.0$ $\quad \Sigma\Theta^2 f = 647062.50$
$\Sigma\Theta^2 = 38750.00$ $\quad S(\Theta^2) = 15443.50$
$\Sigma\Theta^3 = 1750000.000$ $\quad S(\Theta^3) = 687500.000$
$\Sigma\Theta^4 = 85156250.0000$ $\quad S(\Theta^4) = 36718750.0000$
$\Sigma f = 421.7$ $\quad S(f^2) = 679.33$
$\Sigma\Theta f = 14492.50$ $\quad S(\Theta f) = 2929.76$
$\quad S(\Theta^2 f) = 119937.50$

$\alpha_s = 8.431$
$\beta_{1s} = 0.266$

Review These Points About Statistics

THE NORMAL DISTRIBUTION

If it were possible to measure all of the values of some fixed variable in an isolated system or "universe" that is subject to the random action of inherent errors, the values of the variable, which shall be designated x, would scatter around a mean value in such a manner that a plot of frequency of value as a function of value would yield the function

$$f = \frac{1}{\sigma\sqrt{2\pi}} \exp \frac{-(x-\mu)^2}{2\sigma^2}, \qquad (1)$$

where σ^2 is a measure of the dispersion of x around the mean, μ, and is called the variance. This function is known as the normal distribution curve and is illustrated in the accompanying figure.

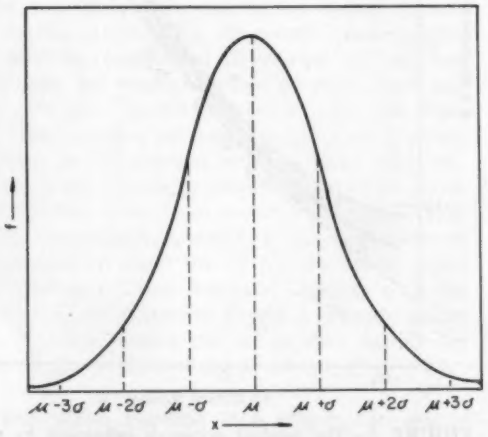

FIGURE 5—Here is a normal frequency distribution curve.

A complete integral analysis of the normal distribution curve would show that of the total population of x,

38.3% of the points fall in a bracket $\mu \pm 0.5\ \sigma$,
68.3% of the points fall in a bracket $\mu \pm 1.0\ \sigma$,
86.6% of the points fall in a bracket $\mu \pm 1.5\ \sigma$,
95.5% of the points fall in a bracket $\mu \pm 2.0\ \sigma$,
98.8% of the points fall in a bracket $\mu \pm 2.5\ \sigma$,
99.73% of the points fall in a bracket $\mu \pm 3.0\ \sigma$,
and 99.99% of the points fall in a bracket $\mu \pm 4.0\ \sigma$,

where σ is the square root of the variance and is called the standard deviation of the distribution.

The range of values listed above can be related to the probability that a value of x will lie in a particular range of values. It is customary, however, to make the relationships more general by performing the substitution

$$u = \frac{x-\mu}{\sigma}, \qquad (2)$$

in which the deviation of the variable x is said to be expressed in "standard measure." When this substitution has been made, the probability values can be arranged as in Table 1A, which gives, for any value x in a normally-distributed universe, the probability that the stated value of u will not be exceeded.

TABLE 1A
Normal Distribution

u	P(%) that u Will Not Be Exceeded
0.5	38.3
1.0	68.3
1.5	86.6
2.0	95.5
2.5	98.8
3.0	99.73
4.0	99.99

Since a normally distributed variable with a mean μ_o

$\beta_{2s} = 0.0017$
$V(\beta_{1s}) = (0.038)^2$
$V(\beta_{2s}) = (0.00078)^2$
$s^2_{fs\Theta\Theta^2} = 3.73$
$t_{\beta_{2s}} = 2.18$

q	5.0	2.5
t @ 28 DF:	2.05	2.40

$t_{q=5.0} < t_{\beta_{2s}} < t_{q=2.5}$ therefore β_{2s} not significant

Recalculations for curve: $f_s = \alpha_s + \beta_s\Theta$

$\alpha_s = 9.36$ $t_{\beta_s} = 6.875$ $V(\beta_s) = (0.0225)^2$
$\beta_s = 0.1546$ $s^2_{fs\Theta} = 7.8227$

t @ 29 DF @ q = 2.5: 2.40 therefore β_s highly significant

Confidence Limits

q = 5.0 29 DF
β_s: $0.1110 < b_s < 0.1982$

f_o @ Θ_o:		
	$\Theta_o = 0$:	$7.73 < f_o < 10.99$
	$\Theta_o = 50$:	$15.70 < f_o < 18.65$
	$\Theta_o = 75$:	$18.60 < f_o < 23.40$

TABLE 4

Large Particle Analysis: Temperature-Octane Curve

Θ = temperature — C_1 f_L = octane number — C_2
For curve: $f_L = \alpha_L + \beta_{1L}\Theta + \beta_{2L}\Theta^2$

$n = 11$ $\Sigma f^2 = 1312.64$
$\Sigma\Theta = 325.0$ $\Sigma\Theta^2 f = 226375.000$
$\Sigma\Theta^2 = 15625.00$ $S(\Theta^2) = 6022.70$
$\Sigma\Theta^3 = 859375.000$ $S(\Theta^3) = 397727.300$
$\Sigma\Theta^4 = 51953125.0000$ $S(\Theta^4) = 29758523.0000$
$\Sigma f = 108.6$ $S(f^2) = 240.40$
$\Sigma\Theta f = 4355.00$ $S(\Theta f) = 1146.40$
$S(\Theta^2 f) = 72114.000$

$\alpha_L = 3.13$
$\beta_{1L} = 0.258$
$\beta_{2L} = 0.001$
$V(\beta_{1L}) = (0.114)^2$
$V(\beta_{2L}) = (0.0016)^2$
$s^2 f_{L\Theta\Theta^2} = 9.439$
$t_{\beta_{2L}} = 0.625$

8 DF	5.0	2.5
	2.31	2.80

$t_{q=5.0} > t_{\beta_{2L}} < t_{q=2.5}$ therefore β_{2L} not significant

Recalculation for curve: $f_L = \alpha_L + \beta_L\Theta$

$\alpha_L = 4.265$ $t_{\beta_L} = 9.410$ $V(\beta_L) = (0.0202)^2$
$\beta_L = 0.190$ $s^2 f_L\Theta = 2.4457$

t @ 9 DF @ q = 2.5: 2.70 therefore β_L highly significant

Confidence Limits

q = 5.0 9 DF
β_L: $0.1435 < \beta_L < 0.2365$

f_o @ Θ_o:		
	$\Theta_o = 0$:	$2.55 < f_o < 6.05$
	$\Theta_o = 50$:	$12.35 < f_o < 15.25$
	$\Theta_o = 75$:	$16.23 < f_o < 20.97$

and a standard deviation σ_o will rarely give a value u greater than 3.0 (approximately 1 in 400), it can be concluded that it is highly improbable that any set of x which yields a value of u greater than 3.0 is of the same universe as μ_o and σ_o.

It should be noted here that although most statistical techniques are based upon the concept of normality, all phenomena do not occur naturally in this form. It has been stated, however, that conclusions reached upon the basis of normally distributed data are not seriously affected by moderate departures of the data from normality.[1]

Since most experimental work involves relatively small numbers of samples, the previous discussion is not directly applicable without modification. These modifications for a small number of samples are as follows:

Let it be assumed that there exists an experimental system for which a mean and a standard deviation have been estimated by the equations

$$\mu_{est} = m = \frac{\Sigma x_i}{n}, \qquad (3)$$

$$\sigma_{est} = s = \sqrt{\frac{\Sigma(x_i - m)^2}{n-1}}, \qquad (4)$$

where x_i is the value of an individual measurement, and n is the total number of experiments. The divisor in equation 4, n-1, is referred to as the number of degrees of freedom of the statistic s, and clearly demonstrates the dependence of s on the number of experiments. Although s is the estimated measure of the dispersion of points around the mean calculated from a single set of points, additional samplings of the same system would result in a set of means that are normally distributed around an average or most probable mean. Accordingly, any single set of datum points must be corrected to include this limitation of the estimated mean. The reliability factor is called the "standard error of the mean," and is defined by the equation

$$\text{S.E. (m)} = \frac{s}{\sqrt{n}} \qquad (5)$$

This statistic, rather than the standard deviation, must be used for all statistical comparison in systems in which the numbers of samples are relatively small.

Since the calculated values of the mean and standard error are only estimates of the true values for a system, the normal probability table previously described cannot be used. In place of this table, a probability table adjusted for the number of degrees of freedom used to calculate s has been developed. This table is called the "Student" t-table, and is used in the same manner as Table 1. The statistic t, which is defined by the equation

$$t = \left| \frac{x - m}{\text{S.E. (m)}} \right|, \qquad (6)$$

expresses the measurement in a type of standard measure, and is completely analogous to the statistic u, which was defined previously. Differences in values between the t-table and normal-probability table arise from the fact that the values of t are function of the number of degrees of freedom used to calculate s. With large numbers of samples, the t-table and normal-probability table become equivalent, as shown in Table 2A.

TABLE 2A

Comparison of t and u (Single-Sided t Table)

D.F.	t At Various P(%) 10	5.0	2.5	1.0	0.5
1	3.08	6.31	12.7	31.8	63.7
5	1.48	2.01	2.57	3.36	4.03
10	1.37	1.81	2.23	2.76	3.17
20	1.32	1.72	2.09	2.53	2.85
30	1.31	1.70	2.04	2.46	2.75
60	1.30	1.67	2.00	2.39	2.66
120	1.29	1.66	1.98	2.36	2.62
∞	1.28	1.64	1.96	2.33	2.58
u	1.28	1.64	1.96	2.33	2.58

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TABLE 5

Small Particle Analysis: Octane-Aromatics Curve

f = octane number — Q_1 $\quad A_s$ = aromatics — Q_2

For curve: $A_s = \alpha_s + \beta_{1s}f + \beta_{2s}f^2$

$n = 31$ $\quad \Sigma A^2 = 1444.12$
$\Sigma f = 111.7$ $\quad \Sigma f^2A = 5591.928$
$\Sigma f^2 = 1081.81$ $\quad S(f^2) = 679.33$
$\Sigma f^3 = 6611.149$ $\quad S(f^3) = 2713.144$
$\Sigma f^4 = 65866.0237$ $\quad S(f^4) = 28114.0000$
$\Sigma A = 38.2$ $\quad S(A^2) = 240.40$
$\Sigma fA = 1071.94$ $\quad S(fA) = 934.30$
$S(f^2A) = 4258.859$

$\alpha_s = -4.345$
$\beta_{1s} = 1.253$
$\beta_{2s} = 0.0305$
$V(\beta_{1s}) = (0.091)^2$
$V(\beta_{2s}) = (0.014)^2$
$s^2_{Aff^2} = 3.44$
$t_{\beta_{2s}} = 2.18$

q	5.0	2.5
t @ 28 DF	2.05	2.40

$t_{q=5.0} < t_{\beta_{2s}} < t_{q=2.5}$ therefore β_{2s} not significant

Recalculation for curve: $A_s = \alpha_s + \beta_s f$

$\alpha_s = -3.720$ $\quad t_{\beta_s} = 6.875$ $\quad V(\beta_s) = (00757)^2$
$\beta_s = 1.375$ $\quad s^2_{Af} = 3.8726$

t @ 29 DF @ q = 2.5: 2.40 β_s highly significant

Confidence Limits

$q = 5.0$ $\quad$ 29 DF

β_s: $1.220 < b_s < 1.530$

A_o @ f_o: $\quad f_o = -10$: $\quad -19.71 < A_o < -15.23$
$f_o = 0$: $\quad -4.615 < A_o < -2.825$
$f_o = +10$: $\quad 8.68 < A_o < 11.38$

TABLE 6

Large Particle Analysis: Octane-Aromatics Curve

f = octane number — Q_1 $\quad A_L$ = aromatics — Q_2

For curve: $A_L = \alpha_L + \beta_{1L}f + \beta_{2L}f^2$

$n = 11$ $\quad \Sigma A^2 = 429.24$
$\Sigma f = -1.4$ $\quad \Sigma f^2A = -725.401$
$\Sigma f^2 = 240.64$ $\quad S(f^2) = 240.46$
$\Sigma f^3 = -115.976$ $\quad S(f^3) = -85.349$
$\Sigma f^4 = 9374.8564$ $\quad S(f^4) = 4110.5283$
$\Sigma A = -35.4$ $\quad S(A^2) = 315.32$
$\Sigma fA = 264.57$ $\quad S(fA) = 260.06$
$S(f^2A) = 49.022$

$\alpha_1 = -3.823$
$\beta_{11} = 1.094$
$\beta_{21} = 0.034$
$V(\beta_{11}) = (0.123)^2$
$V(\beta_{21}) = (0.030)^2$
$s^2_{Aff^2} = 3.64$
$t_{\beta_{21}} = 1.13$

q	5.0	2.5
t @ 8 DF	2.31	2.80

$t_{q=5.0} > t_{\beta_{2L}} < t_{q=2.5}$ therefore β_{2L} not significant

Recalculation for curve: $A_L = \alpha_L + \beta_L f$

$\alpha_L = -3.078$ $\quad t_{\beta_L} = 9.380$ $\quad V(\beta_L) = 0.0136$
$\beta_L = 1.099$ $\quad s^2_{Af} = 3.2796$

t @ 9 DF @ q = 2.5: 2.70 β_L highly significant

Confidence Limits

$q = 5.0$ $\quad$ 9 DF

β_L: $0.830 < \beta_L < 1.368$

A_o @ f_o: $\quad f_o = -10$: $\quad -16.99 < A_o < -11.15$
$f_o = 0$: $\quad -4.338 < A_o < -1.818$
$f_o = +10$: $\quad 4.962 < A_o < 10.862$

TABLE 7

Combined Curve: Octane-Aromatics

f = octane number — Q_1 $\quad A$ = aromatics — Q_2

For curve: $A = \alpha + \beta_1 f + \beta_2 f^2$

$n = 42$ $\quad \Sigma A^2 = 1873.36$
$\Sigma f = 110.3$ $\quad \Sigma f^2A = 4866.527$
$\Sigma f^2 = 1322.45$ $\quad S(f^2) = 1032.78$
$\Sigma f^3 = 6495.173$ $\quad S(f^3) = 3022.168$
$\Sigma f^4 = 75240.8801$ $\quad S(f^4) = 33601.03$
$\Sigma A = 2.8$ $\quad S(A^2) = 1873.17$
$\Sigma fA = 1336.51$ $\quad S(fA) = 1329.16$
$S(f^2A) = 4778.364$

$\alpha = -4.166$
$\beta_1 = 1.18$
$\beta_2 = 0.036$
$V(\beta_1) = (0.067)^2$
$V(\beta_2) = (0.0117)^2$
$s^2_{Aff^2} = 3.40$
$t_{\beta_2} = 3.08$

q	5.0	2.5
t @ 39 DF	2.02	2.33

$t_{q=5.0} < t_{q=2.5} < t_{\beta_2}$ β_2 is significant
$q = 5.0$ $\quad$ 39 DF

β_1: $1.05 < \beta_1 < 1.32$
β_2: $0.012 < B_2 < 0.060$

A_o @ f_o: $\quad f_o = -10$: $\quad -14.25 < A_o < -10.49$
$f_o = 2.63$: $\quad -1.64 < A_o < 0$
$f_o = +10$: $\quad 8.94 < A_o < 13.53$

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About the Authors

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Use These Tricks to Speed Up Answers

Here is a simple problem involving trial-and-error calculations. See how general relations help make better first guesses for multicomponent calculations of a hydrodesulfurizer and absorber

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London

A TRIAL AND ERROR calculation can be long and tedious if there is no prior knowledge of the magnitude of the final answer. This problem can be complicated further when the situation involves multicomponent streams, recycles, and liquid-vapor equilibrium flashes. In many cases, however, it is possible to shorten the task with an analysis of the general relations involved in the process.

Hydrodesulfurization Plus Gas Absorber. Here is an analysis of a specific process scheme to show how informed guesstimates can be made for the first trial calculations. An hydrodesulfurization process will be used for an example. The flow diagram for the process is shown in Figure 1.

The hydrogen for the desulfurization is produced in a reforming reaction. Thus the hydrogen offgas from the reformer separator contains heavy ends. Similarly the hydrodesulfurized naphtha leaving the flash drum contains dissolved light ends and hydrogen sulfide. By countercurrently contacting these two streams in an absorber stripper, valuable heavy ends are recovered from the hydrogen stream, and light ends and hydrogen sulfide are removed from the treated naphtha.

The material balance for this system, involving as it does streams containing up to six or more components, must be solved by a trial-and-error method which appears to be complicated by the interrelation between the compositions of the liquid entering and the gas leaving the absorber stripper. The problem can be simplified, however, by an analysis of the conditions which exist for the absorber stripper.

Simplify the Absorber Stripper. The outlet concentration of any component in a stream leaving an absorber or a stripper is given approximately by the expression,

$$\frac{Yb - Yt}{Yb - Ye} = \frac{1 - A^m}{1 - A^{m+1}} \qquad (1)$$

where

Yb = mole fraction of component in vapor entering
Yt = mole fraction of component in vapor leaving
Ye = mole fraction of component in vapor phase for equilibrium with entering liquid
m = Number of (theoretical) plates
$A = \frac{KV}{L}$
and L = Liquid molal flow rate
V = Vapor molal flow rate
K = Equilibrium constant for component

This equation holds strictly for lean mixtures, that is for mixtures containing only small proportions of the components absorbed or stripped. The mixtures which are encountered in practice will often be rich, that is, contain large proportions of components to be absorbed or stripped. In these cases L/V is not constant through the column. Moreover K also varies through the column owing to the appreciable heat of absorption or stripping so that the assumption made in deriving Equation (1) do not hold. Nevertheless the conclusions from Equation (1) will hold, approximately at least, for rich mixtures also.

Thus, if m is large (say about 20 or more) and L/V is roughly equal

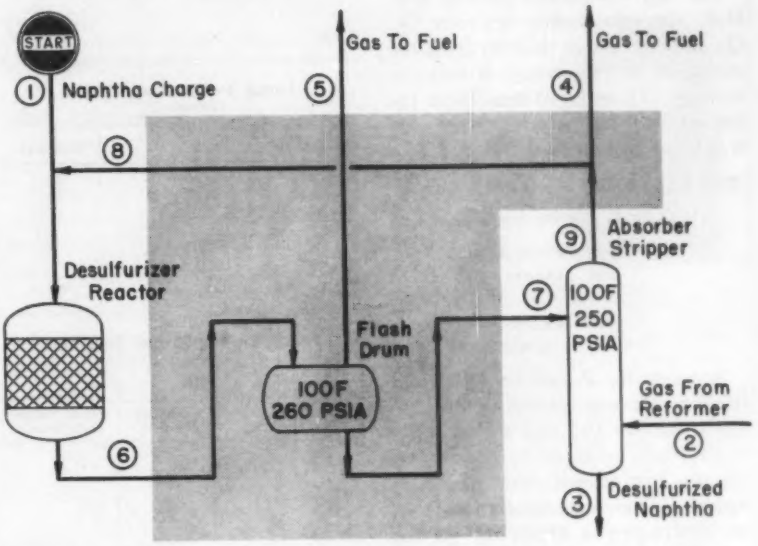


FIGURE 1—The number of trial calculations can be decreased if certain generalizations are made beforehand.

to 1, as in the example which follows, the gas leaving the column will be in equilibrium with the liquid entering the top of the column for components having K's less than 1.

Example Problem. For the sample problem represented in Figure 1, the composition and quantities of only two streams are known—the charge naphtha stream (1) and the reformer offgas (2). Analyses of these two streams are given in Tables 1 and 2. The properties of stream (1) were estimated from true boiling point data. The operating conditions at the top of the absorber stripper are assumed to be 250 psia and 100 F. The values of K, then, for the components involved are shown in Table 3. Thus, in the example that we are considering, for all the components heavier than H_2S there will be equilibrium between the gas and the liquid streams at the top of the column.

Now, if we make a material balance for any component crossing the shaded boundary in Figure 1, Equation 2 follows

$$(Q_6 - Q_8) + Q_9 = Q_7 + Q_5 + Q_4 \qquad (2)$$

where

Q_4 = the quantity of component in stream 4 etc. and $(Q_6 - Q_8)$ is the net flow of component from the hydrodesulfurizer, i.e., the total flow less the recycle (stream 8).

For any component heavier than H_2S, the relationship between Q_4, Q_7 and Q_9 can be derived from the condition of equilibrium between streams (7) and (9) and from the known ratio in which stream (9) is split to give streams (4) and (8).

Thus if $Q_9 = Vy$

$Q_7 = L\ y/k$ for equilibrium

and $Q_4 = ZVy$, where Z is the fraction stream (4) is of stream (9), and y is the mole fraction of the component in stream (9).

A value for Z can be calculated from the known quantity of hydrogen in stream (2) and the quantity of hydrogen required in stream (8) for the hydrodesulfurizer. It is assumed in the first calculations that no hydrogen is absorbed in the absorber-stripper; a more accurate value of Z can be re-calculated later allowing for the small quantity of hydrogen absorbed.

Thus Equation (2) becomes:

$$(Q_6 - Q_8) + Vy = Ly/K + Q_5 + zVy$$

$$\text{or } (Q_6 - Q_8) + Vy\,(1 - Z) = Ly/K + Q_5 \qquad (3)$$

For C_1 through C_5 which are at this stage assumed not to be formed in the hydrodesulfurizer, $(Q_6 - Q_8) = 0$ and since $Q_5 \geqq 0$, Equation (3) may be written:

$$Vy\,(1 - Z) \geqslant Ly/K \qquad (4)$$

$$\text{Then } K \geqslant \frac{L}{V\,(1 - Z)} \text{ or y is zero} \qquad (5)$$

In the case we are considering, the following data are known about the hydrosulfurization reaction:

Hydrogen recycle required ..... 178.5 moles/hr
Hydrogen consumption... 136.5 moles/hr
Hydrogen sulfide production ..... 2.4 moles/hr

Thus, while the reformer off-gas contains 278.5 moles/hr of H_2, only 178.5 moles/hr are required by the hydrodesulfurizer, so that stream (4) contains 100 moles/hr of H_2 as a first approximation. By taking L/V to be approximately equal to the ratio of stream (1) plus H_2S produced to stream (2), the inequality of Equation (5) becomes

$$K \geqq \frac{(454 + 2.4)}{402.6}\left(1 - \frac{100}{278.5}\right)$$

$$\geqq 1.8 \text{ or else y is zero, for } C_1, C_2, C_3, \text{ and } C_5$$

It follows, then, C_3 (K = 0.76), C_4's (K = 0.3) and C_5's will be removed totally from the gas stream by passage through the absorber stripper. For the other components, Equation (1) can be shown to yield the following results:

- For components heavier than C_5 there will be equilibrium at the top of the absorber stripper.
- For hydrogen, methane, ethane and H_2S there will be equilibrium at the bottom of the absorber stripper.

By inspection of the composition of stream (2) and knowing that little H_2 and CH_4 will be absorbed in the absorber stripper, that all C_3, C_4 and C_5 will be absorbed and arbitrarily assuming at this stage that all C_6+ and half the C_2 will be absorbed, gives the total absorption as 63.1 moles. Thus a first estimate of the molal flow rate of stream (3) would be stream (1) plus 63.1 moles/hr, i.e., 517.1 moles/hr. The condition of equilibrium at the bottom of the colum for H_2, CH_4, C_2H_6, H_2S then gives

$$K\frac{Q_3}{\text{Stream (3)}} = \frac{Q_2}{\text{Stream (2)}}$$

$$\text{or } K\frac{Q_3}{517.1} = \frac{Q_2}{402.6} \qquad (6)$$

Substituting values of Q_2 and K for each of the four light components gives first estimates of Q_3, the quantity of each of them absorbed in the liquid leaving the column. This first estimate is given in the first column of Table 4.

For each of these components we can write the following equation expressing the net flow out of the top of the column.

$$Q_9 - Q_7 = Q_2 - Q_3 \qquad (7)$$

i.e., for hydrogen

$$Q_9 - Q_7 = 278.5 - 3.4 = 275.1 \qquad (7a)$$

For C_1

$$Q_9 - Q_7 = 41.9 - 3.6 = 38.3 \qquad (7b)$$

For C_2

$$Q_9 - Q_7 = 38.2 - 18.9 = 19.3 \qquad (7c)$$

For H_2S

$$Q_9 - Q_7 = 0 \qquad (7d)$$

C_3, C_4 and C_5 are absent from the liquid and gas beyond the top of the absorber stripper and it is assumed

TABLE 1—Hydrodesulfurizer Feed
Stream (1)

Component	Moles/Hr
C_6	54
C_7	48
C_8	42
C_9+	310
Total	454

TABLE 2—Reformer Offgas
Stream (2)

Component	Moles/Hr
H_2	278.5
C_1	41.9
C_2	38.2
C_3	27.5
C_4	9.7
C_5	4.6
C_6+	2.2
Total	402.6

TABLE 3—Equilibrium Constants

Component	K @ 100 F	
	Absorber (250 psia)	Flash Drum (260 psia)
H_2	106	102
C_1	15	14.5
C_2	2.6	2.5
H_2S	1.9	1.8
C_3	0.76	.....
C_4's	0.3	.....
C_5's	0.13	.....
C_6's	0.05	0.048
C_7's	neg	neg

TABLE 4—First Estimates of Stream Composition

Stream	(3)	(9)	(8)	(4)	(6)	(5)	(7)
Component							
H_2	3.4	275.1	178.5	96.6	42.0	38.9	3.1
C_1	3.6	38.3	24.9	13.4	24.9	16.0	8.9
C_2	18.9	19.3	12.6	6.7	12.6	3.0	9.6
H_2S	0	0	0	0	2.4	0.4	2.0
C_3+	—[1]	0	0	0	454.0[2]	0.3	453.7
Total	...	332.7	216.0	116.7	535.9	58.6	477.3

[1] No estimate needed at this point.
[2] Distribution same as for stream (1)

TABLE 5—Final Answers for Stream Composition

Stream	(3)	(9)	(8)	(6)	(7)
Component					
H_2	3.4	279.9	178.5	42.0	2.8
C_1	3.6	48.8	31.2	31.2	10.5
C_2	18.9	37.2	23.7	23.7	17.8
H_2S	0	4.0	2.5	4.9	4.0
C_3	27.5	0	0	0	0
C_4	9.7	0	0	0	0
C_5	4.6	0	0	0	0
C_6	453.2	2.1	1.4	55.4	55.1
C_7		0.75	0.48	48.5	400.7
C_8		0.28	0.18	42.2	
C_9+		0	0	310	
Total	520.9	373.0	238.	557.9	490.9

at this stage, that heavier components also are absent from the gas phase beyond the top of the absorber stripper.

The trial-and-error calculation is commenced by assuming that each of the light components is absent from stream 7, i.e., that each Q_7 in Equations 7 (a), (b), (c) and (d) is zero. This assumption allows a first estimate to be made of the relative quantities of the streams in the absorber stripper/hydrodesulfurizer section.

Thus from Equations (7) stream (9) is 332.7 moles/hr. The split between streams (4) and (8) will be fixed by the known hydrogen requirement of the hydrodesulfurizer.

In this case, from the first approximation stream (9) contains 275.1 moles/hr of H_2 and 178.5 moles/hr of H_2 are required by the hydrodesulfurizer, i.e., Z is 0.351 and the ratio of stream (8) to stream (4) is 178.5 : 96.6; i.e., stream (8) is 216 moles/hr, stream (4) is 116.7 moles/hr made up as shown in Table 4.

The hydrogen consumption in the hydrodesulfurizer will also be known and will be high in the case of olefinic naphtha. In the example under consideration the consumption is 136.5 moles/hr. The desulfurization reaction produces 2.4 moles/hr of hydrogen sulfide and we have assumed no production of light ends, thus the quantity of stream (6) is 535.9 moles/hr with the composition shown in Table 4.

The composition and quantities of streams (5) and (7) are calculated by the normal flash equilibrium method. For 100 F. and 260 psia, refer back to Table 3 for the equilibrium constants, K. The calculated compositions of the streams (5) and (7) are added to Table 4.

Thus based on the original approximation that stream (7) contained no H_2, H_2S, C_1 and C_2, a composition for this stream has been rapidly calculated by "working around" the flow diagram. The whole procedure is now repeated "working around" the flow diagram as before starting with the composition of stream (9). From the new composition obtained for stream (7) the procedure can be repeated until successive trials produce only small changes. In practice a convergence will be obtained after only two or three sequences of calculations. The final answers for this example are given in Table 5.

This rapid convergence to a final answer is due to the "informed guess" which is possible for the first approximation, i.e., that there are no light ends in stream (7). Since we have previously established (ignoring light ends production in the hydrodesulfurizer) that C_3, C_4 and C_5 are absent beyond the top of the absorber stripper, this is a fairly close approximation. If the calculations were commenced with arbitrary concentration of light ends, including C_3 and C_4 in stream (7) the trial-and-error calculations would be unnecessarily protracted.

Once the flow quantities of all the streams are known fairly accurately it is possible to calculate explicitly the quantities of C_2 and H_2S in each stream by an over-all mass balance. Thus for H_2S, for equilibrium, since none of this component leaves in the liquid phase, 2.4 moles/hr. must leave in the two gas purges. If the mole fraction of this component in streams (9), (8) and (4) is X, then the purge in stream (4) is 130X moles/hr. (since we know stream (4) is approximately 130 moles/hr). Similarly if the mole fraction in stream (5) is Y, then the purge here must be 66 Y. This gives the equation

$$130X + 66Y = 2.4 \text{ moles/hr} \quad (8)$$

Also for vapor-liquid equilibrium the mole fraction in stream (7) is Y/1.8 and by mass balance around the hydrodesulfurizer and flash drum we get the equation

$$235X + 2.4 = 66Y + 490Y/1.8$$

$$\text{i.e., } 338Y = 235X + 2.4$$

$$Y = 0.695X + .0071 \quad (9)$$

and substituting in Equation (8) gives

$$Y = .01475 \quad X = .011.$$

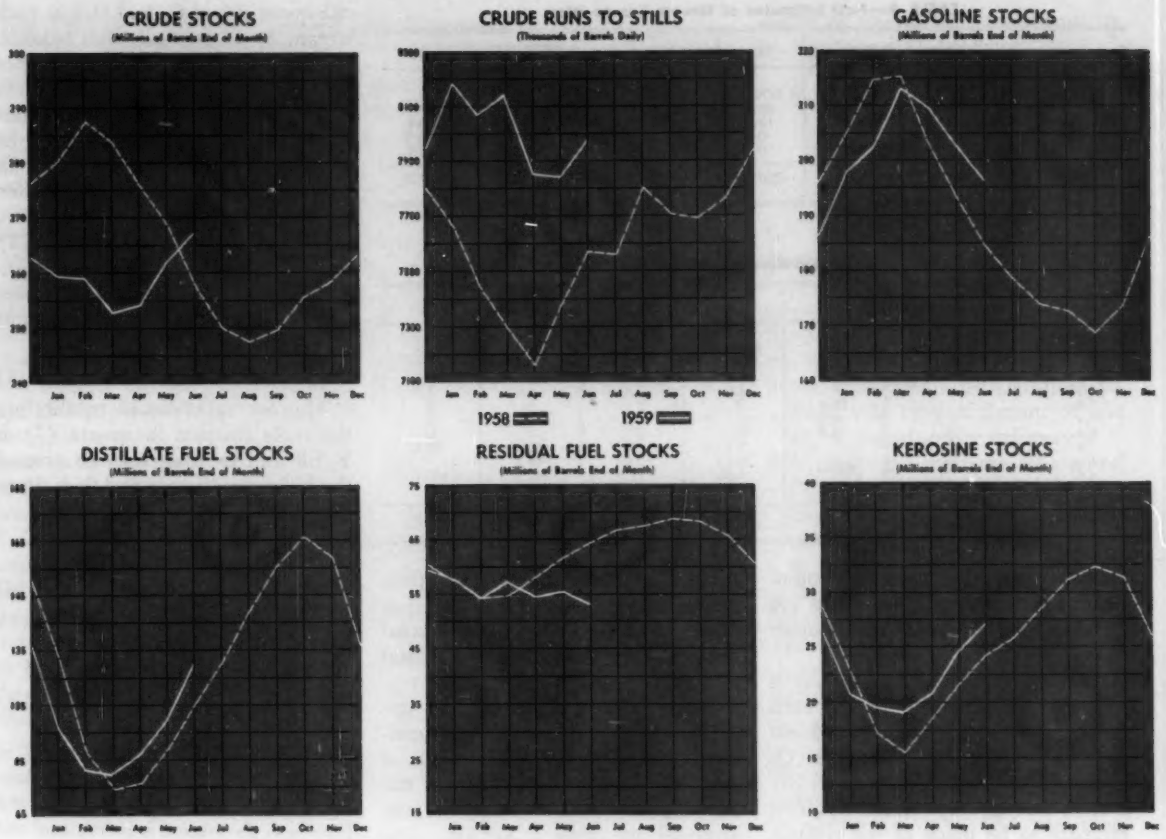
Thus stream (7) contains 4 moles/hr. H_2S, etc.

Similarly the quantities of C_2 in each stream can be quickly calculated from a mass balance since the flow into the system is given, and the flow out in the liquid from the absorber stripper is already fairly accurately known.

A correction can also be made in same way to allow for small quantities of light ends formed in the hydrodesulfurizer. ##

About the Author

Alfred Doll-Steinberg is a process engineer for Foster Wheeler, Ltd., London, England. His duties include the process design of cracking and reforming plants. Doll-Steinberg attended Cambridge University where he graduated with first-class honors. He spent a year with Foster Wheeler Corp., New York, from January to December, 1957, having first joined Foster Wheeler, Ltd., London, in June, 1956.



Taking Stock

- Crude stocks continue to rise
- Runs to stills up sharply
- Residuals drop again

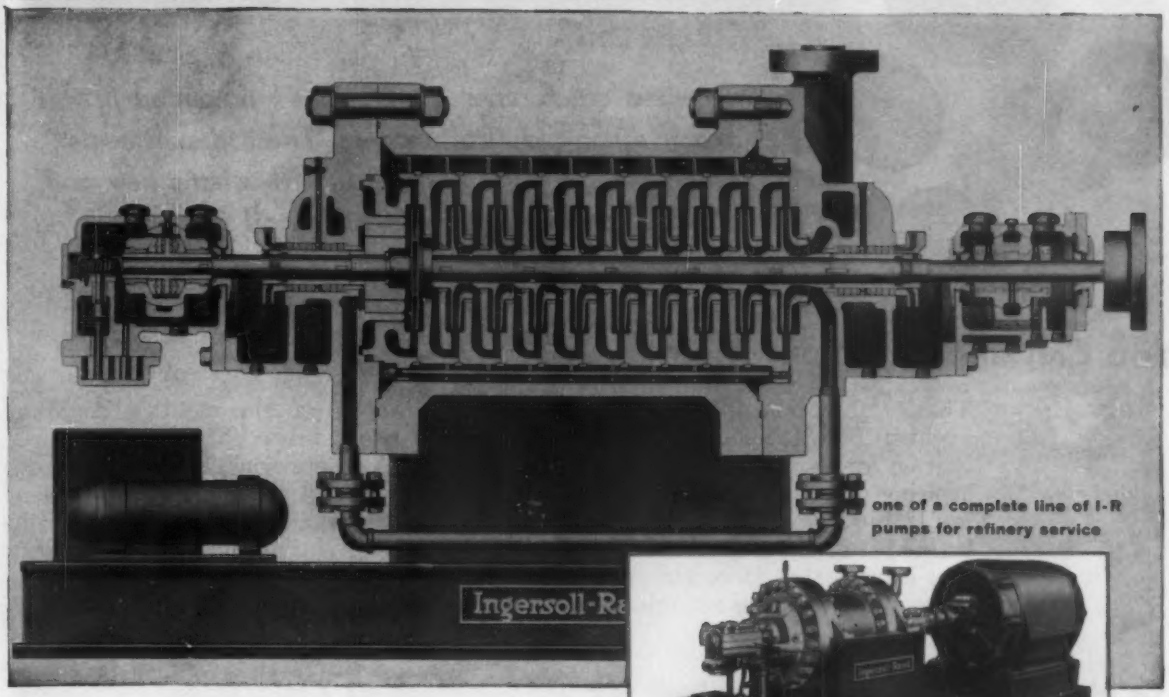
U.S. Petroleum Demand and Supply (Thous. Bbls. Daily)

ITEM	June 1959	June 1958	June % Diff.	May 1959	January-June 1959	January-June 1958	January-June % Diff.
DEMAND							
All Oils, Total Demand	8,737	8,509	+ 2.7	8,651	9,763	9,253	+ 5.5
Domestic Demand	8,487	8,259	+ 2.8	8,406	9,511	8,988	+ 5.8
Export Demand	250	250	.....	245	252	265	— 4.9
Gasoline, Total Demand	4,350	4,251	+ 2.3	4,157	4,003	3,831	+ 4.5
Distillate, Total Demand	1,162	1,115	+ 4.2	1,337	2,017	1,951	+ 3.4
Kerosine, Total Demand	186	145	+28.3	132	318	332	— 4.2
Residual, Total Demand	1,378	1,209	+14.0	1,384	1,767	1,529	+15.6
Other Oils, Total Demand	1,661	1,789	— 7.1	1,641	1,658	1,610	+ 3.0
CHANGE IN STOCKS							
All Oil, Change in Stocks	790	235	.....	865	148	367	.....
NEW SUPPLY							
Total New Supply	9,527	8,744	+ 9.0	9,516	9,911	8,886	+11.5
Domestic Production, Total	7,864	7,085	+11.0	8,033	8,045	7,244	+11.1
Crude Oil	7,002	6,341	+10.4	7,183	7,175	6,464	+11.1
Natural Gas Liquids	862	744	+15.9	850	870	780	+11.5
Imports, Total	1,663	1,659	+ 0.2	1,483	1,866	1,641	+13.7
Refined Products	494	699	—29.3	559	914	703	+30.0
Crude Oil, Total	1,169	960	+21.8	924	952	939	+ 1.4
Crude, East Coast	906	750	+20.8	754	749	772	— 3.0
CRUDE RUNS							
Crude Runs to Stills	7,993	7,527	+ 6.2	7,843	8,044	7,446	+ 8.0
Domestic Crude	6,949	6,547	+ 6.1	6,947	7,112	6,522	+ 9.0
Foreign Crude	1,044	980	+ 6.5	896	932	924	+ 0.9

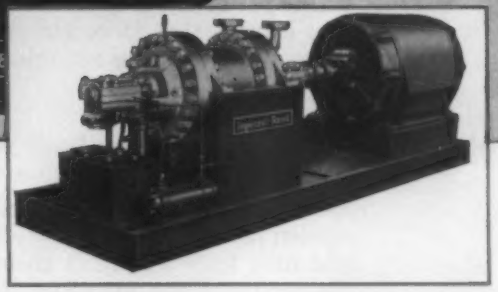
U.S. Stocks of Oils (Million Bbls. at End of Month)

KIND OF OIL	TOTAL IN U.S. June 1959	TOTAL IN U.S. June 1958	TOTAL IN U.S. % Diff.	TOTAL IN U.S. May 1959	EAST OF CALIFORNIA June 1959	EAST OF CALIFORNIA June 1958	EAST OF CALIFORNIA % Diff.	EAST OF CALIFORNIA May 1959
All Oils	810.0	774.9	+ 4.5	786.3	.....	.....	.....	.....
Crude Oil	268.1	253.6	+ 5.7	262.4	233.9	208.3	+12.3	226.7
Gasoline	195.9	186.3	+ 5.2	203.3	167.0	160.3	+ 4.2	174.1
Distillate Fuel Oil	119.7	105.3	+13.7	99.6	106.5	92.0	+15.8	90.1
Kerosine	27.4	24.2	+13.2	24.7	27.0	23.8	+13.4	24.0
Residual Fuel	54.2	63.9	—15.2	55.1	28.1	31.5	—10.8	28.5
Other Oils	144.7	141.6	+ 2.2	141.2	.....	.....	.....	.....

NEW INGERSOLL-RAND CHARGE PUMPS
Offer Longer Life on High-Pressure Process Service



one of a complete line of I-R pumps for refinery service



. . . featuring proved "Unit-Type" Rotor Assembly

The new Ingersoll-Rand CMR pump is specifically designed for high-pressure process service, where operation without a spare requires top performance and exceptional dependability. It is a horizontal, multi-stage unit with vertically-split barrel-type casing, suitable for a wide range of low-capacity, high head applications in refineries or other process plants.

Available in 1½ and 2½ inch discharge sizes, the CMR pump will efficiently handle capacities up to 400 gpm, pressures to 1500 psi and temperatures to 750°F.

Some of the outstanding features are noted below. For complete information, contact your Ingersoll-Rand representative.

FEATURES:

- **High-Strength Casing** . . . The main barrel is made from centrifugally-cast steel with forged steel ASA flanges welded at both ends. The nozzle head and discharge head are one-piece carbon steel castings which bolt to the casing flanges. The main casing joints are sealed with confined flexitallic gaskets. The pump can be dismantled without disturbing the piping connections.
- **"Unit-Type" Rotor Assembly** consists of separate channel ring segments, impellers and shaft. It can be easily removed from the pump as a unit to facilitate maintenance.
- **Impellers and Wearing Rings** . . . The single-suction, closed type impellers are cast in one piece and mechanically balanced to assure smooth, vibration-free operation. Casing rings, pressed into the channel rings, and locked against rotation, are easily renewed to maintain close running clearances.
- **Hydraulic Balance** . . . Multiple-volute diffusor construction completely eliminates radial thrust. A balancing drum effectively counteracts axial thrust due to pressure differentials across each stage. Residual thrust is taken up by the thrust bearing.
- **Bearings** . . . Spherically seated, self-aligning Kingsbury thrust bearing and sleeve-type radial bearings are pressure lubricated by a gear oil pump driven from the outboard end of the shaft. An oil reservoir and shell and tube-type cooler are mounted on the pump base.

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PUMPS • COMPRESSORS • GAS & DIESEL ENGINES • AIR & ELECTRIC TOOLS • TURBO BLOWERS • CONDENSERS

Valuable Reading Ahead

Here's a quick run-down on what's presented in this month's non-technical sections. These departments will keep you right up-to-date with what's new and different in this rapidly changing oil industry.

You Can Improve Your Memory!

That's right, and all you have to do is read the lead story in this month's "As Management Sees It . . ." section. As you no doubt know, this is the section which is written for those persons in managerial or supervisory positions, and also for those aspiring to such positions. In How to Remember: Part 1, "Sharpen Your Learning Habits," you'll find that you can't really forget something if you never really learned it in the first place. Therefore, the first step to improving your memory is to learn better. Here are some learning techniques which will enable you to develop your power of retention—and remembering. You'll want to . . .

Keep going to page 175

Up the Ladder

Yes, each month hundreds of the industry's men go "up the ladder"—the promotion ladder, that is. New jobs are opened—old jobs are filled by new men, and you may know many of them. Take a look at "Men in Industry" to see what's happening to the people you know, and those you would like to know. Simply . . .

Keep going to page 221

Who's Meeting Where

You'll find out when you read PETROLEUM REFINER's "Meetings Calendar"—that easy-to-read tabulation of what's coming up in the societies and associations that are of most interest to you. For a handy "calendar of events" to clip out and keep so you can refer to it at a moment's notice, . . . **Keep going to page 218**

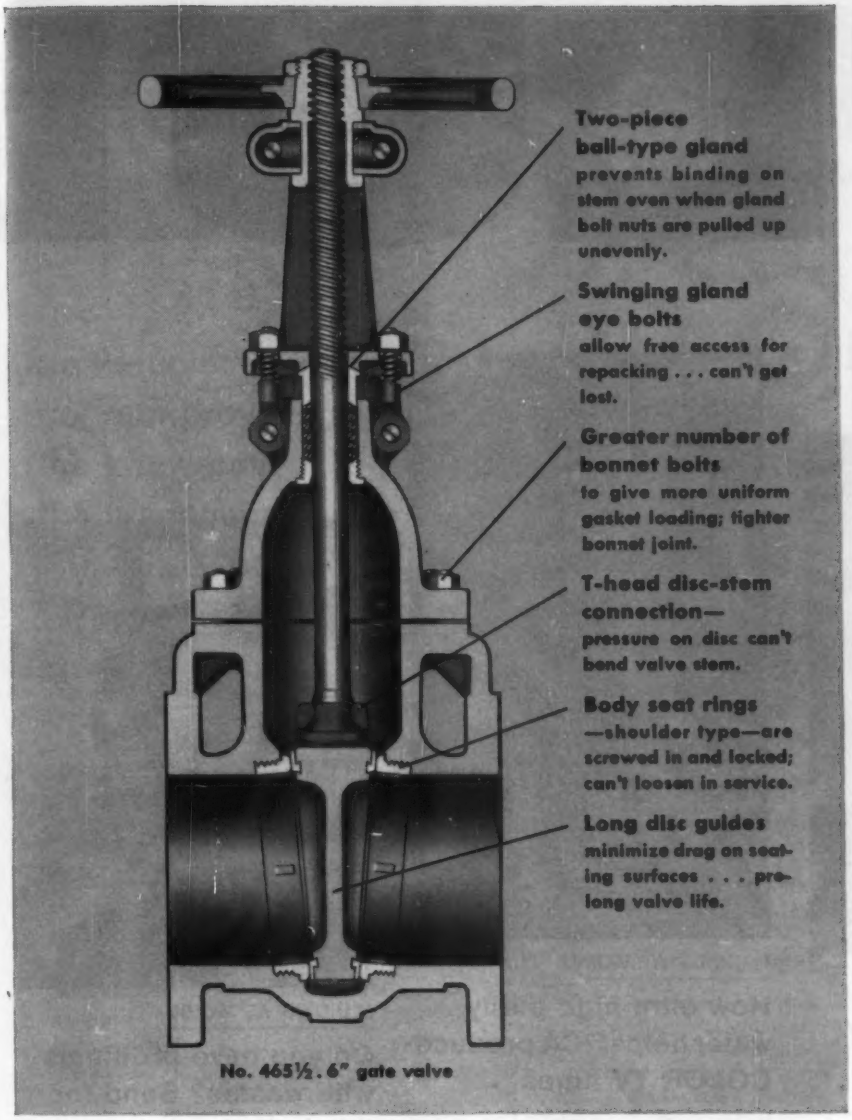
My! Times Do Change

That's why you should read "Changing Times," a fast moving account of those items that made news in the industry last month. It is just what the doctor ordered for busy industry men who don't have time to wade through many paragraphs to get the meat of the subject. To learn more . . . **Keep going to page 216**

What's Happening

To make sure you're informed of major news developments in the industry last month, read "What's Happening," a fast moving summary of the latest news about the people, places and things in your field. It's just what the doctor ordered for busy men who don't have time to read long accounts of oil news. You'll see for yourself when you . . .

Keep going to page 207


Two-piece ball-type gland
prevents binding on stem even when gland bolt nuts are pulled up unevenly.
Swinging gland eye bolts
allow free access for repacking . . . can't get lost.
Greater number of bonnet bolts
to give more uniform gasket loading; tighter bonnet joint.
T-head disc-stem connection—
pressure on disc can't bend valve stem.
Body seat rings
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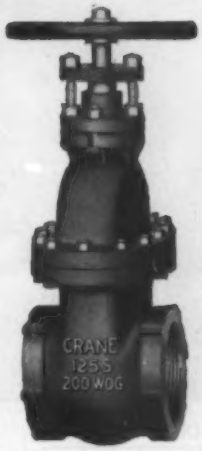
Long disc guides
minimize drag on seating surfaces . . . prolong valve life.

No. 465½. 6" gate valve

No. 465½. 125-Pound, OS&Y, bronze trimmed. Flanged ends. 2" to 48". Also in all-iron.



No. 460. 125-Pound, non-rising stem. Bronze trimmed; screwed ends. 2" to 8". Also in all-iron (to 4" only).

Most suitable utility valves for refineries

CRANE 125-POUND IRON BODY GATES

In the pump house, in water mains, in steam and various oil service lines . . . in a variety of other low-pressure applications, refineries depend on Crane 465½ iron body, bronze trimmed gate valves.

The cross section above reveals some of the advantages in improved valve design that assure dependable operation and long life, and make these valves easy to maintain.

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Other iron body valves are available in globe, angle, check, quick-opening and double-disc patterns, both flanged and screwed ends. For complete specifications, consult your Crane Representative or write directly to us.

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PIPE • PLUMBING • HEATING • AIR CONDITIONING

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FLUI

FLUIDICS AT WORK

Data on ion exchange as a unique unit operation

Have you considered ion exchange as a unit operation?

If you're used to thinking of ion exchange as only a method for purifying boilerfeed and process waters, you will be glad to learn that this same process can be a valuable aid in performing other functions.

Ion exchange is often far more efficient than other type unit operations, particularly where solutions are dilute—less than 2500 ppm, generally speaking.

We'll be glad to send you data concerning ion exchange usage for removing impurities from solution, for concentration and separation of dilute electrolytes in solution, for addition of specific ions to solution, and for catalysis, both acidic and basic.

We'll also send complete information on Permutit ion exchange resins and process equipment. Just circle "A" on the coupon.

FLUIDICS AT WORK

How ultra high purity water helps RCA produce COLOR TV tubes

Water used for washing the inside surfaces of RCA color TV picture tube envelopes must be ultra pure. Even a trace of iron or copper might discolor or deaden the sensitive phosphor coating that reproduces the color picture.

At RCA's Lancaster plant, washing was first done with distilled water. When tube production outgrew the capacity of the distillation equipment, RCA put in its first manually operated ion exchange units. When these, too, fell short of requirements, RCA called in Permutit to enlarge and modernize the complete demineralizing facilities.

Now the entire process is operated from one master control panel. There's plenty of water for production . . . and dissolved mineral content is even lower than when the water was distilled.

For more information on this process we refer you to the item on the left and to the letter "B" on the coupon.

FLUIDICS AT WORK

Do you have problems with wastes? Send for this bulletin

Here in eight pages you'll find concise comments on modern methods and equipment used for controlling, treating, and reclaiming industrial wastes.

The bulletin covers such knotty problems as reclaiming chromates, acids, and other valuable materials . . . removing fats and greases . . . neutralizing waste waters . . . complying with anti-pollution laws . . . etc.

Equipment described includes Precipitators, Colloidair Separators, chemical feeders, filters, ion exchange units, evaporators, meters and flow controllers, and CO_2 indicators.

There is also an outline of the complete engineering and testing services available from Pfaudler Permutit.

If waste *is* one of your problems and you want to know some of the practical answers, just circle "C" on the coupon for a copy.

DICS

is a Pfaudler Permutit program providing the know-how the equipment and the experience for solving problems involving fluids.

FLUIDICS covers such varied phases of fluid handling and control as:

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polymerization
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fluid analysis, metering and control
agitation
evaporation
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drying
blending
metering
valving
flow rate control
piping
storing
centrifuging
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heat transfer, etc.

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FLUIDICS AT WORK

For low-cost gas analysis or control

If the gas component you want to measure or control is related to the specific gravity of the gas, a RANAREX will measure it accurately, continuously, without lag and at low cost.

Works on a simple, mechanical principle . . . rugged, foolproof. Can be equipped for automatic control. Analyzes flue gas to cut fuel costs . . . aids quality control in heat-treating, chemical processing, oil refining . . . checks uniformity of fuel gas, etc.

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Glassed ductile iron* fittings with strength comparable to Glasteel's

Now you can get glassed, ductile iron fittings that are 2½ to 3 times as strong as conventional gray iron.

60,000# tensile strength, 45,000# yield, 15% elongation.

Thermal shock resistance is now comparable to Glasteel 59's. Corrosion resistance is also the same as Glasteel's . . . handles all acids except hydrofluoric.

July 1st delivery on 45° and 90° elbows, tees, and crosses in 1½-, 2-, 3-, 4-, and 6-inch sizes.

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*Patent Pending

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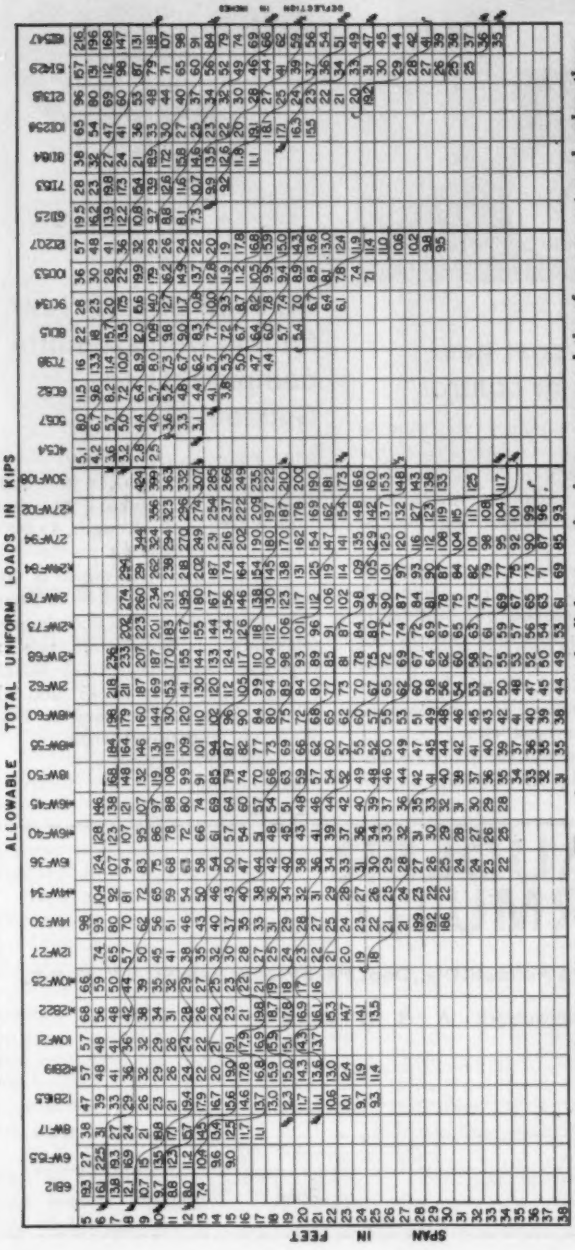
How to Do It...

Table Gives Economical Beam Loads

Popular beams from the AISC Steel Handbook are tabulated in the same sequence as in the section modulus table



* Check with vendors for these beams. These beams are not the lightest section in a group and therefore are not used unless there is a repetition. Tabulations are for ASTM A-7 steel. Tabulations are taken from the AISC economical section table and adding several frequently used sections. Curved lines indicate deflection in inches and dashed lines show maximum allowable shear on web. Example: 18 Kips on 20′—0″ span = 12WF27 (Capacity 23 Kips). 10WF25 = 131 Kips, underized.

The AISC steel handbook tables can be made even handier by tabulating the beams in the capacity table in the same sequence as the section modulus table. This allows a beam to be sized by referring to only the one table. At the same time, the more unpopular beams are eliminated from the picture. For these, the AISC handbook can be used.

For example, the load carrying capacities of all the beams are tabulated in the AISC handbook so you can find a beam to carry the design load. The beam selected may or may not be the most economical, so it becomes necessary to check your selection versus the economical section modulus table. The tabulation printed here eliminates this cross check.

These AISC tables have been combined so the "unpopular" beam sizes are minimized. Asterisks appear along side those that we prefer not to use. The Channel and "I" beam tables are included because of their popularity. Their economy isn't related to the wide flange beams.

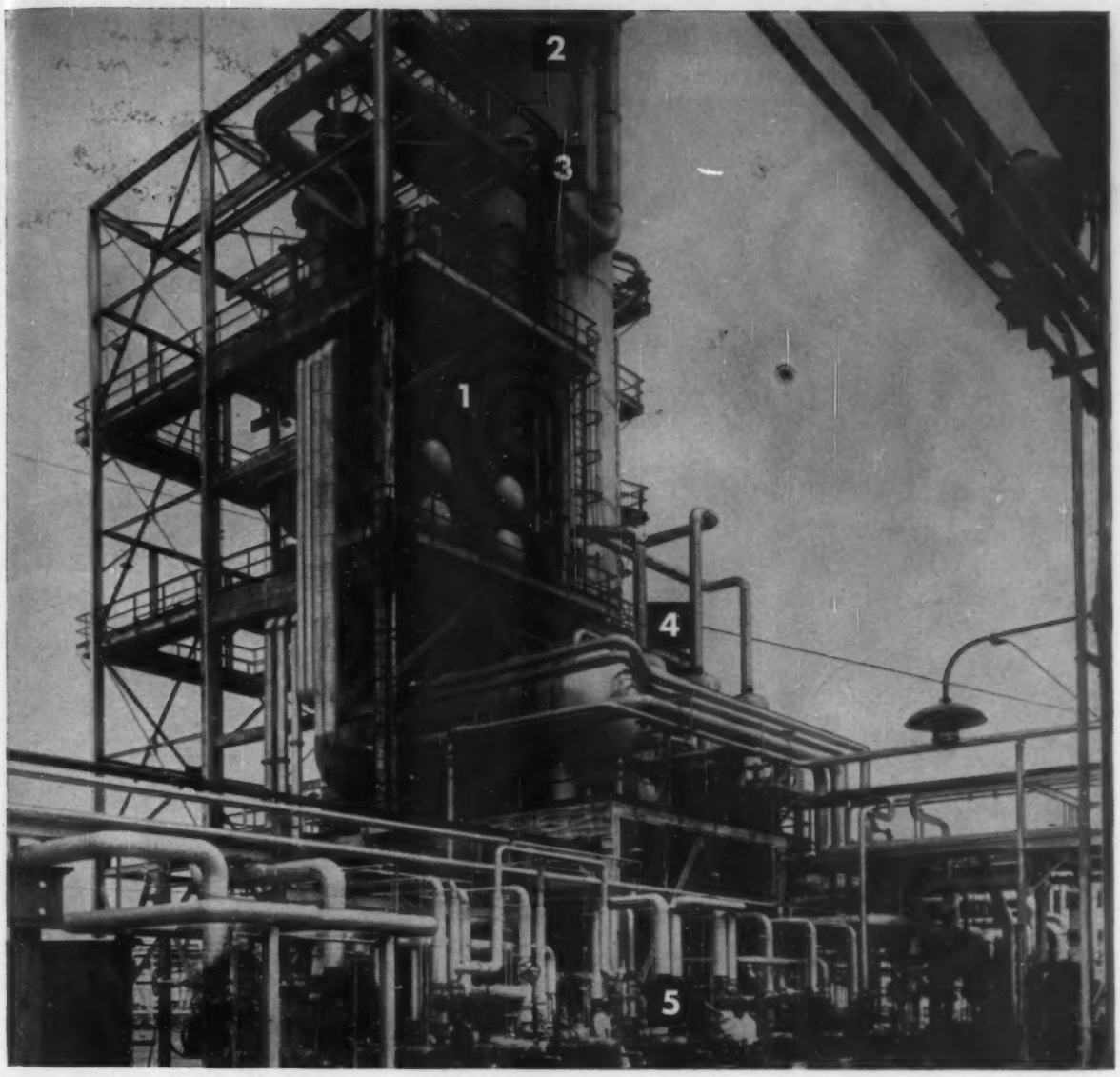
The deflection can be estimated at the time the beam is selected by simply noting the deflection boundary curves.

The table has been made assuming uniform loads but concentrated loads may also be found exactly as is done with the AISC tables. The allowable concentrated load (at the center of the span) is half that shown in the table.

Beams must be laterally supported as indicated in the table. The loads next above the heavy line for each tabulation is the maximum allowable shear on the web as in the AISC handbook.

Example. Assume that a beam is uniformly loaded at 900 pounds per foot on a 20-foot, 0-inch span. The total load on the beam is 900 x 20 = 18,000 pounds or 18 Kips. Look in the table along the 20-foot, 0-inch span line until the load equals or exceeds the 18 Kip load. The 12 WF 27 would be selected as it will support 23 Kips uniformly. The next lighter beam, the 10 WF 25, will carry only 17 Kips—1 Kip shy.

Note that the 10 WF 25 is marked with an asterisk. The section modulus table in the AISC handbook lists it as an economical beam section. In the AISC handbook, it is grouped with the 10



5-point Monel "program" combats corrosion in Creole's 100,000 bbl crude unit

1. Atmospheric overhead condensers—Lukens Monel-clad steel on shell side.

2. Atmospheric tower — 20% Monel-clad on top head and top 11'6" of shell.

3. Atmospheric tower— top 4 trays of Monel alloy.

4. Distillate drum — 20% Monel-clad throughout, nozzles Monel lined.

5. Pumps handling naphtha product and reflux—shafts of "K"* Monel age-hardenable nickel-copper alloy; impeller, lantern and case wearing rings and packing gland of "H"* Monel semi-hard cast alloy; impeller wearing ring of "S"* Monel hard grade cast alloy; Duraseal of Monel alloy.

Creole Petroleum Corporation at Amuay Bay, Venezuela . . . and Foster Wheeler Corporation of New York City . . . took full advantage of the corrosion-resisting properties of Monel* nickel-copper alloys at five trouble-spots to combat corrosion . . . corrosion from dilute mineral acids, by sulfur and naphthenic contents of the feed.

Monel alloy resists corrosion by aqueous solutions of hydrogen sulfide and hydrochloric acid. Chloride traces, which can cause corrosion, and particularly at temperatures below 300°F, can be handled with Monel alloy. This high nickel alloy resists wet carbon dioxide, too.

How can Monel alloy fit in your refinery's program to combat corrosion?

Contact us for help with your corrosion problems. No obligation.

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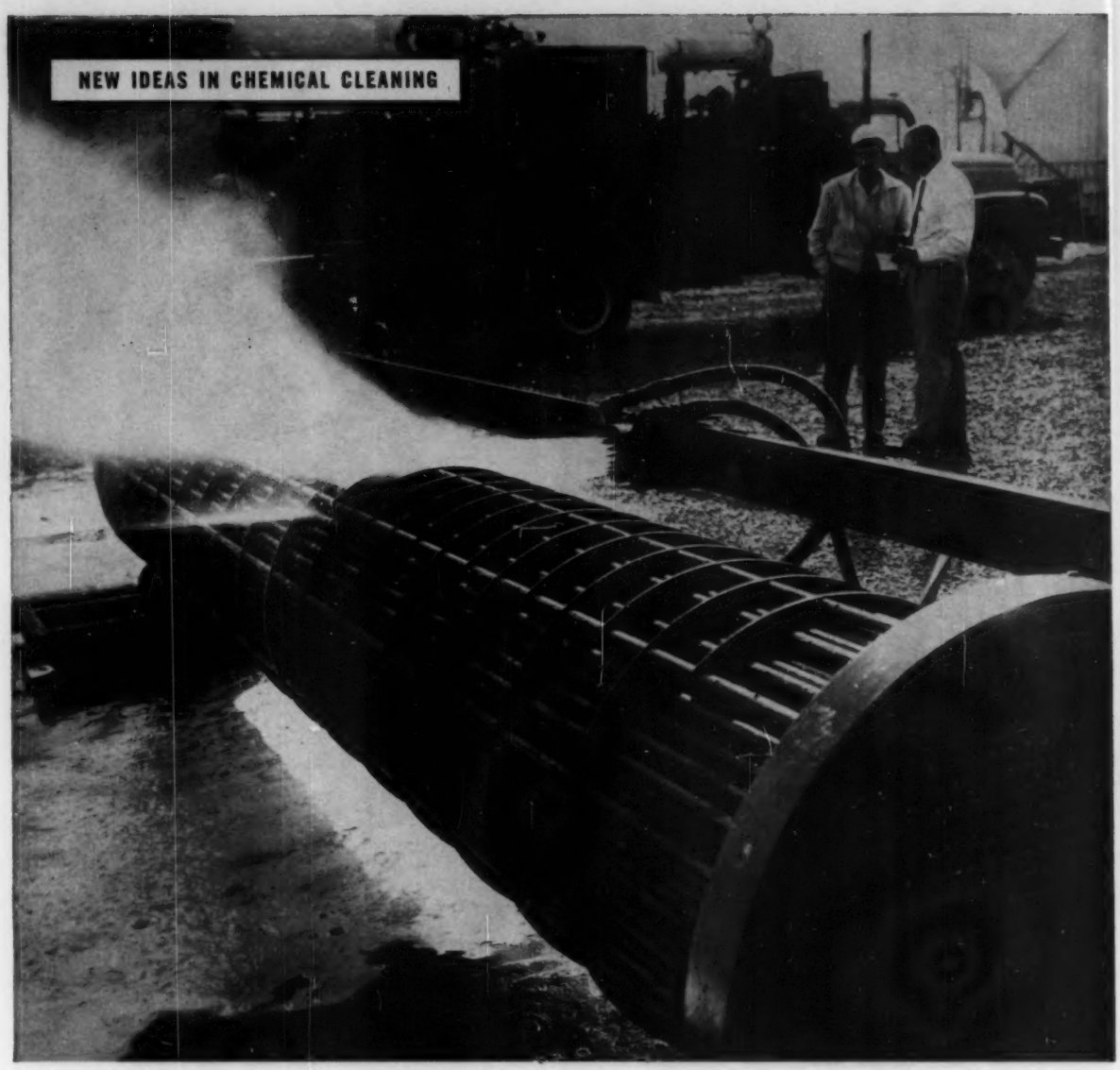


New Jetting Tool To Clean Tube Bundles Saves Thousands Of Dollars

The new high-pressure hydraulic tool, shown above, is currently saving thousands of dollars for companies in the refining, chemical, and petrochemical industries. It is the jetting tool developed by Dowell to remove deposits from heat exchanger tube bundles.

Previous methods of cleaning these bundles have been costly, time-consuming and often inadequate. Many times bundles had to be replaced completely because of the lack of a suitable cleaning method.

This new Dowell tool has a remarkable record of thorough, fast cleaning. For example, a slurry reboiler exchanger bundle, three feet in diameter and 16 feet long, was fouled with deposits of coke and asphalt. After being jetted from only one side, the bundle was thoroughly clean. Time required: less than one hour.

The tool holds the bundle in place for cleaning and has flanged rollers for rotation. The jet-head is manipulated automatically so that all tube spaces are covered. The jetted liquid can be either water or chemical solvents.

This high-velocity jetting device is another example of the new ideas Dowell continues to offer in chemical cleaning to help you cut your costs. Whatever the cleaning problem in your plant, call Dowell for an engineered recommendation. Dowell — the largest, the oldest, the most experienced chemical cleaning service — Tulsa 1, Oklahoma; and 165 stations and offices in major industrial centers.

Chemical cleaning service for all industry DOWELL

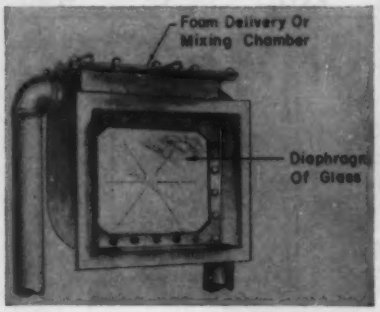
DIVISION OF THE DOW CHEMICAL COMPANY

How To Do It . . .

WF 21 which is the lightest in the group. Since the lightest beam in a group is usually more popular, it is good practice to stay away from the heavier beams in a group. Of course, if several beams are required, the saving in steel will likely justify its use and the fabricator can order from the mill if he doesn't have the beam in stock.

Fabricators generally prefer to order from the mill since they can order to correct length. This saves cutting off ("off-fall") part of a stock length beam to provide a specific dimension. With the larger beams this becomes a major loss in pounds, so these beams should be ordered from the mill if possible.

This item was submitted by James G. Brown of James G. Brown & Associates, Houston.



Foam Chamber Diaphragm Glass Needs Special Care

Cone roof tanks and other atmospheric pressure tanks having vapor spaces generally justify the installation of permanent facilities for foam application, in case of fire.

Mixing chambers are attached to the shell of the tank near its upper rim. In order to isolate the foam system from the tank in service, these mixing chambers are, under normal conditions, sealed from the tank atmosphere by diaphragms of glass, lead or other suitable weak materials which will break when foam pressure is applied.

Some considerations in the use of glass diaphragms are:

- The glass should be not weak enough to rupture at normal tank working pressures, but should break easily when foam is applied.
- When the foam pressure is applied, the glass diaphragm is expected to be completely broken. Any frag-

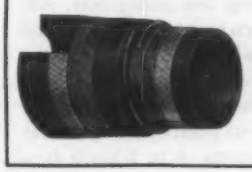
20% lighter than cotton duck but just as sturdy and flexible... Quaker Thermoid OS&D Hose

Strong but light. Extremely rugged but flexible. That's Thermoid-Quaker "Quaflex" Oil Suction and Discharge Hose.

It's lighter than reinforced cotton-duck hose, but it won't expand under pressure. It won't collapse under suction. It's exceptionally kink- and crush-resistant.

For more details, call your local Thermoid distributor, or write to *Thermoid Division, H. K. Porter Company, Inc., Tacony and Comly Streets, Philadelphia 24, Pa.*

HERE'S WHY: Separate layers of nylon tire cord surround a helix of high-tensile spring-steel wire in Thermoid-Quaker "Quaflex" Oil Suction and Discharge Hose. That's why it's just as sturdy and flexible as cotton duck, although lighter in weight.



Nylon tire cord for lightness, strength.

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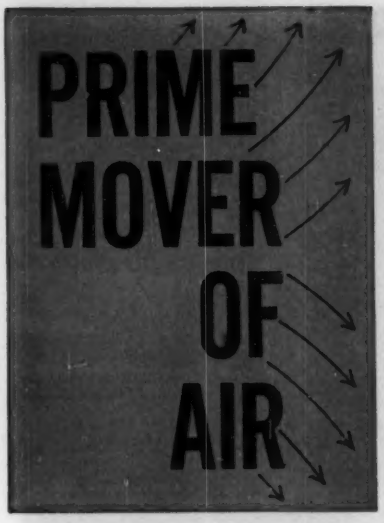

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Aeromaster Fans move *hot* air more efficiently by delivering *more* CFM and requiring less horsepower. Adjustable pitch heat-treated aluminum alloy blades have excellent corrosion-resistance qualities. Used in refineries, gas transmission stations, steel mills and industrial plants for major heat transfer systems. 4 to 6 blade fans available 54″ to 22′ diameters. For more details on fans that cost less to install, operate and maintain, write: KOPPERS COMPANY, INC., 8108 Scott St., Baltimore 3, Md.

KOPPERS Aeromaster Fans

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How To Do It . . .

ments of glass remaining in the diaphragm frame are objectionable, because they will reduce the free area of the foam delivery chamber. This, in turn, decreases the foam delivery rate resulting in nonuniform distribution of foam inside the tank, if two or more chambers are employed.

- In case the diaphragm is partially broken, the remaining fragments should be destroyed unless an extremely high pressure is maintained by a large foam flow rate. Under this condition, part of the foam bubbles are collapsed and destroyed by compression forces as they pass through the narrow gate.

Recommended practice in the use of glass color diaphragms for foam delivery chambers:

Before placing the diaphragm in the chamber, the tank side of the glass plate is cut with six radial grooves on its surface, using a diamond knife. The fine grooves are extended radially from near the center of the diaphragm to the outer edge and equally spaced at an angle of 60 degrees, as shown in the illustration.

When the foam pressure is applied, the diaphragm is quickly broken along the precut rupturing grooves. Since the grooves are made on the tank side, the strength of the glass against the tank working pressure is not affected.

This idea was submitted by Tzen-Yung Yang, Chinese Petroleum Corp., Koahsiung, Taiwan.

Operating Pressure P.S.I.G.	"C"	"K"	Operating Pressure P.S.I.G.	"C"	"K"
20	.03217	.20240	105	.00981	.11179
25	.02868	.19111	110	.00943	.10958
30	.02513	.17890	115	.00907	.10751
35	.02267	.16991	120	.00875	.10557
40	.02067	.16226	125	.00831	.10290
45	.01915	.15617	130	.00797	.10074
50	.01784	.15073	140	.00765	.09870
55	.01645	.14473	150	.00719	.09574
60	.01527	.13946	160	.00679	.09303
65	.01434	.13513	170	.00644	.09057
70	.01351	.13119	180	.00612	.08829
75	.01299	.12860	190	.00583	.08618
80	.01213	.12427	200	.00556	.08419
85	.01154	.12122	225	.00500	.07981
90	.01100	.11835	250	.00454	.07606
95	.01060	.11618	275	.00417	.07293
100	.01023	.11413	300	.00386	.07015

Table Solves Steam Nozzle, Annulus Area

To find the diameter in inches of a steam nozzle when the operating pressure and steam consumption are known, use the following equation:

Dia. Nozzle = "K" $\sqrt{\text{lb. Steam/min.}}$

To find the area of an annulus when the operating pressure and steam consumption are known, use the following equation:

Area of Annulus = "C" (Lb. Steam/Min.)

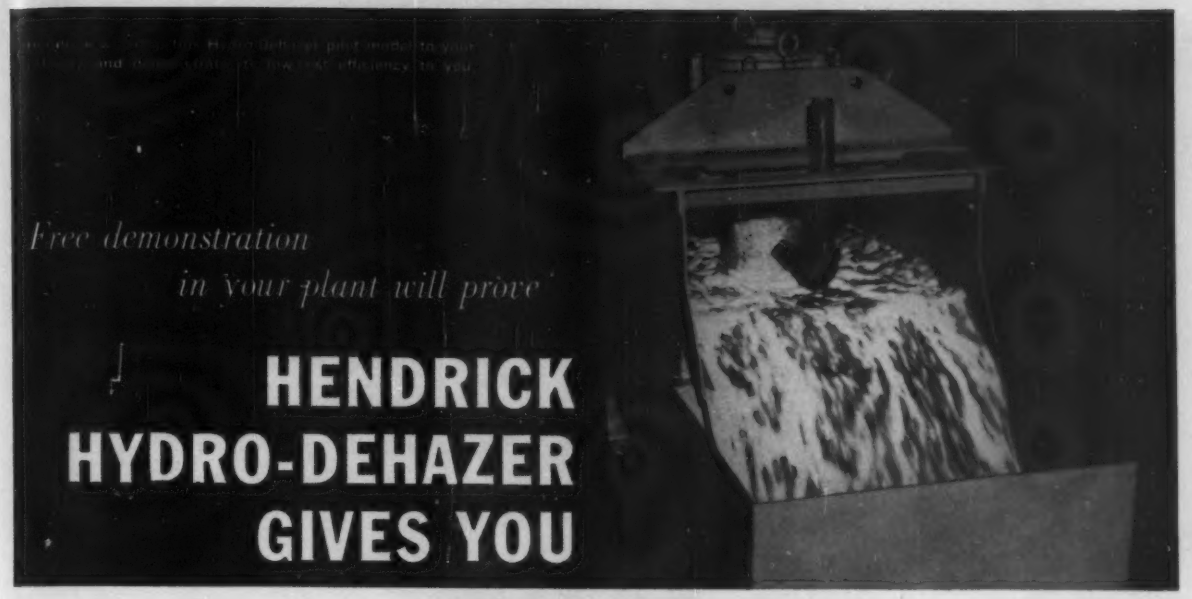
The table gives the values of "K" and "C" for the steam pressure indicated. Values of the "K" and "C" factors can be interpolated for intermediate pressures.

These equations can also be used for determining steam consumption when nozzle diameter or annulus area and pressure are known.

This idea was submitted by J. E. Gammie, Penberthy Manufacturing Co., Detroit.

$$ Your Ideas Are Valuable! $$

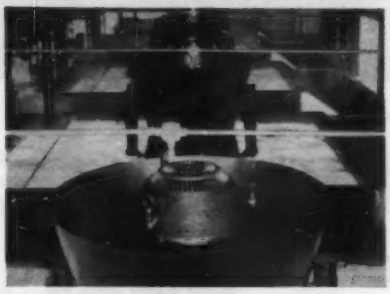
At least $10.00 will be paid for each idea accepted for "How To Do It." All you need to do is write a brief note telling about your idea, then attach a photo or sketch (if needed), and mail it to Editor, Petroleum Refiner, P. O. Box 2608, Houston.



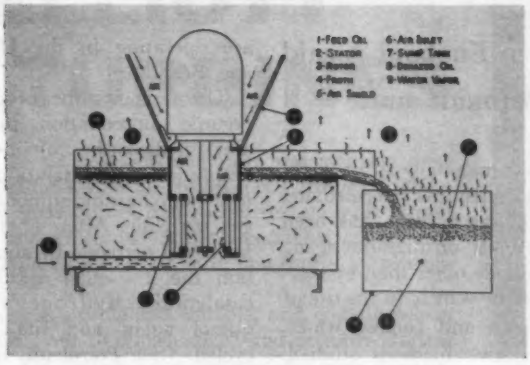
Free demonstration in your plant will prove

HENDRICK HYDRO-DEHAZER GIVES YOU

LOWEST OPERATING COST!



Hendrick Hydro-Dehazer is really economy-minded ... removes moisture for only 25¢ per 1,000 barrels.



The Hendrick Hydro-Dehazer requires no compressed air, high heat, chemicals or other additives. As a result, it removes haze from refinery oils at very low cost — and quickly, too. This economy and speed have been proven in installations which show that Hendrick has the most efficient method — and the lowest operating cost — of all moisture-removal methods. Hendrick will be happy to prove its point in your plant. Just clip the coupon for more information.

Capacity of the Hendrick Hydro-Dehazer is rated at 400 bph for Diesel and No. 2 fuel oil at an inlet temperature of 130°F and a haze point of 35°F to 70°F.

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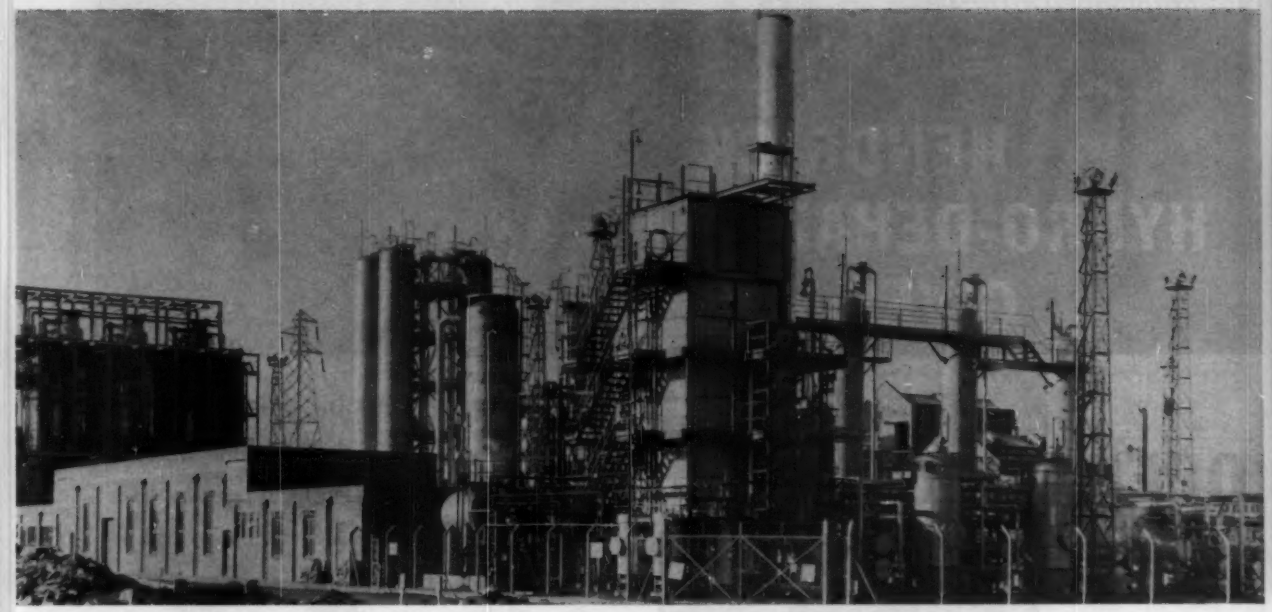


Hydrogenation is carried out in vertical vessels using palladium on an inert support in free suspension.

Laporte Doubles Peroxide Capacity

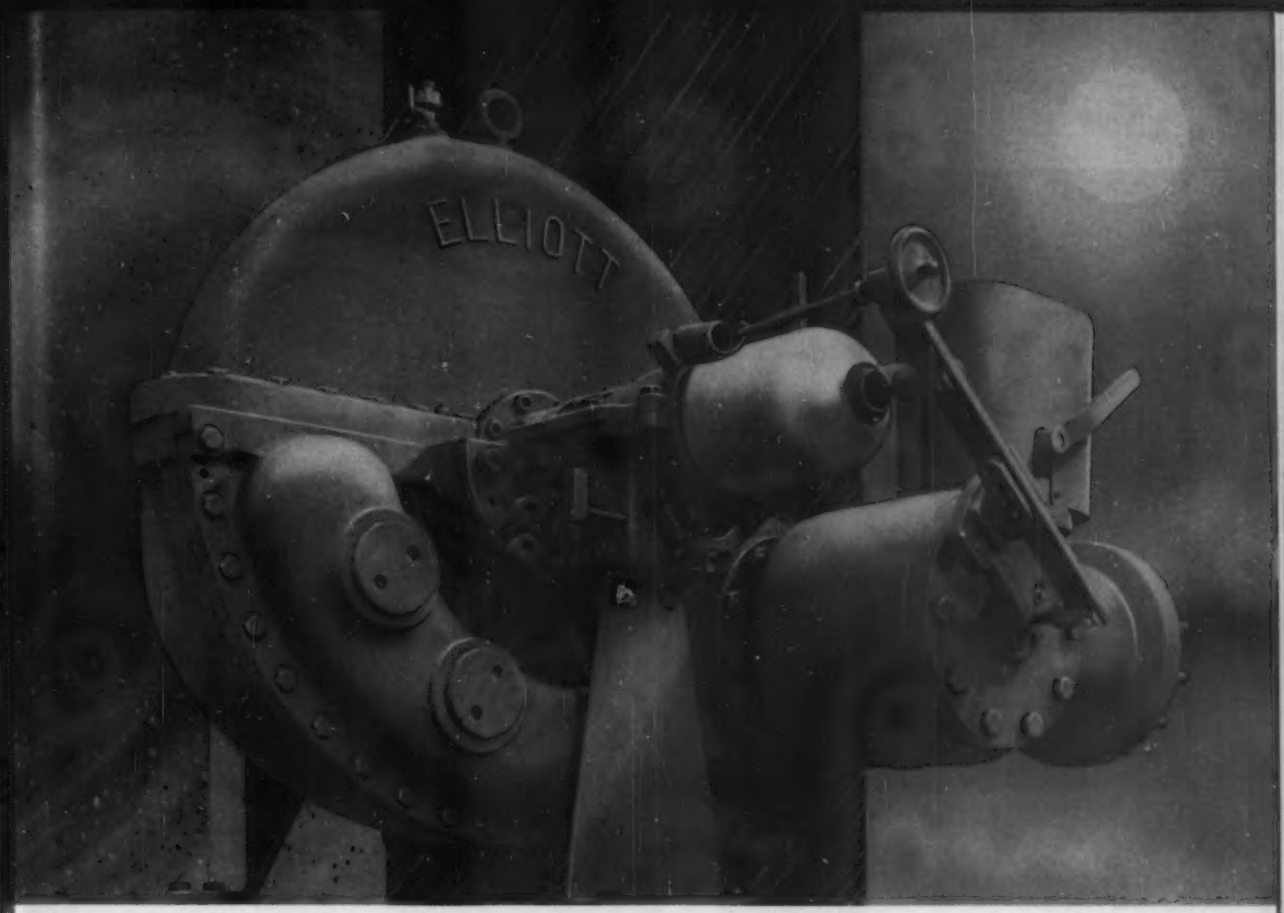
New $7-million plant on stream in England is said to be world's largest hydrogen peroxide unit

Claimed to be the only chemical plant of its kind in Britain and the largest in the world, a peroxide fuel plant has been put into production at Warrington, England, by Laporte Chemicals Ltd. The new $7-million plant will help the company, largest in the Laporte Industries Ltd., group, to double its output of high-strength hydrogen peroxide (known as high-test peroxide or "HTP") at much reduced cost. Apart from selling HTP to the aircraft industry as a fuel for rockets and guided weapons, Laporte will also supply the product to the Royal Navy for use as a torpedo propellant and for two experimental submarines. Hydrogen peroxide will also be available commercially as a bleaching agent and chemical intermediate.

Since 1954, much work has been done on methods of manufacturing hydrogen peroxide other than by electrolytic processes—costly in the use of electricity, steam and cooling water. Of the alternative methods studied, the one receiving most attention employs organic intermediates, particularly substituted anthraquinols, which autoxidize to form hydrogen peroxide. This process is based on work carried out by I. G. Farbenindustrie during the war. It has since been further developed by companies in several countries, and a number of plants are operating in the United States and Belgium.

Theoretically, the process involves organic autoxidation in which an alkyl hydroanthraquinone 2 - ethyl anthraquinol) in solution is oxidized to 2 - ethyl anthraquinone and hydrogen peroxide. After separation of the hydrogen peroxide by aqueous extraction the 2 - ethyl anthraquinone is catalytically hydrogenated to the quinol again and the solution recycled. (See Petroleum Refiner, Vol. 36, No. 11, p. 256).

The process used by Laporte Chemicals was developed by its Research and Development Departments at Luton, England. Plant design work and construction was handled by the Group Engineering Construction Department, London. Main contractors for the plant were the Aluminium



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The governor is simple and reliable, and is available in several modifications to match speed and pressure control requirements. YR turbines are designed for easy installation and service. Many key parts are interchangeable for various frame sizes. Four sizes are shown at the right. Write for descriptive bulletin H22-C.

In addition to the units illustrated here, Elliott makes single-stage turbines in special frames, reduction gears, multistage mechanical drive turbines to 50,000 hp, and turbine-generators through 44 mw.

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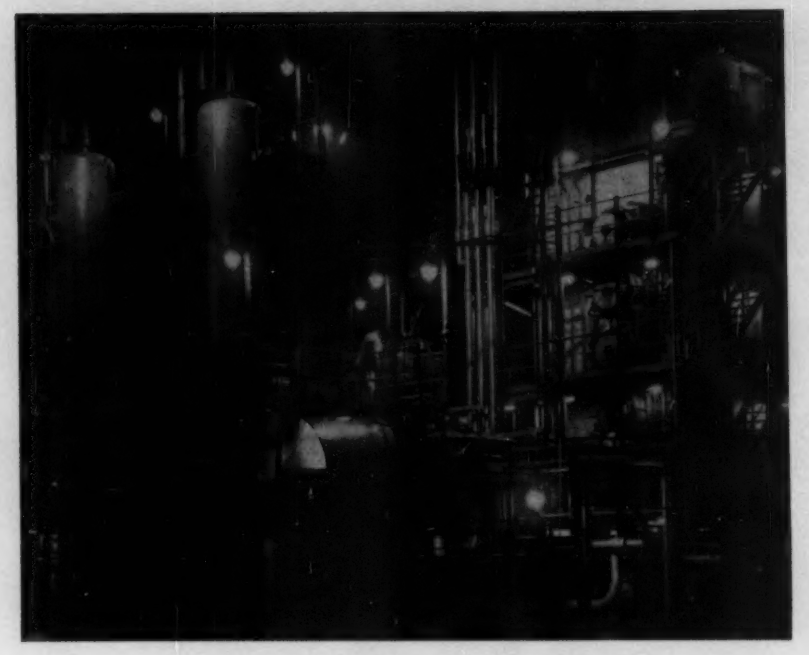


Laporte Chemical's hydrogen unit is fully instrumented.

Plant and Vessel Co., Ltd., and Matthew Hall and Co., Ltd.

Hydrogen is made by cracking butane from the Stanlow refinery. This plant was supplied and built by Power Gas Corp., Ltd.

Almost all equipment for the autoxidation process organic cycle is in the open and consists of two identical units operating in parallel up to the extraction stage, where solution from both streams mixes.

Components are fabricated in aluminum, aluminum alloys, stainless steels and stoneware. The plant is fully instrumented—all flows and pressures are automatically controlled.

Hydrogenation is carred out in vertical vessels using palladium on an inert support in free suspension as the catalyst, this being manufactured on the site. Suspension of the catalyst is accomplished by use of a stream of hydrogen passed through the reactor at more than the theoretical requirement, the excess being recirculated together with fresh hydrogen. The catalyst is added to the reactor at a rate necessary to maintain the required rate of reaction. Hydrogenated solution passes through filters which retain the catalyst in the hydrogenator.

Because both the hydrogenation and oxidation reactions are exothermic, the filtered solution is cooled before being passed to the oxidizers. The latter are vertical vessels and the solution and air are fed to the base so the flow is co-current. On leaving the reactor's top, the gas/liquid mixture is separated, excess air passing through active carbon beds for recovery of evaporated process solvents before going to the atmosphere.

Hydrogen peroxide is extracted from the organic solution using counter-current flow in columns fitted with perforated plates. Because the organic solution is less dense than water it is fed to the base of the columns. The aqueous feed is de-ionized water prepared with mixed resin bed exchange units, to which a stabilizer and corrosion inhibitor are added. The aqueous product, which is withdrawn at a constant rate, contains about 20 percent hydrogen peroxide. After passing through a treatment stage for removal of dissolved organic compounds it is held in run-down tanks for checking of quality.

Although the 20 percent hydrogen peroxide may be used directly for certain purposes, it is normally further purified and concentrated to 50-90 percent hydrogen peroxide by distillation. This is done on a site adjoining that of the organic cycle, and again the plant is largely in the open. The vaporizers are of the vertical tube and shell type with recirculation, the vapor/liquid mixture passing to a separator. The vapor is fractionated in a column using direct reflux, the columns either being fitted with plates or packed with ceramic rings to yield a product with a concentration maintained at the desired level in the 50-70 percent hydrogen peroxide range. The overhead product, mainly water vapor, is condensed by jet spray condensers. Distillation is carried out at reduced pressure, maintained by steam ejectors.

Part of the production from these stills is purified further and converted to 85-90 percent hydrogen peroxide or HTP. The hydrogen peroxide solutions are delivered from the site in 99.5 percent aluminium rail tankers, or by road is smaller containers.

Used to supply air for the oxidation stage, the air compressors are high-speed rotary machines capable of delivering more than 3,000 cubic feet-per-minute at a delivery pressure of 40 psig.

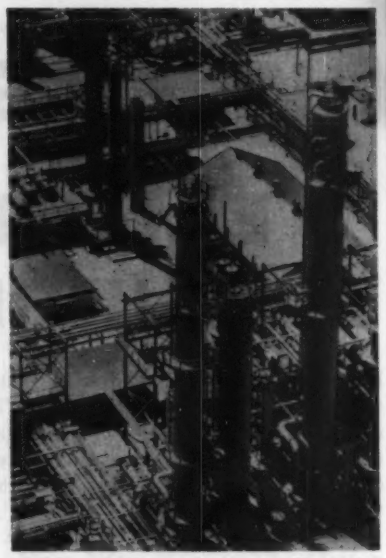
The hydrogen compressors are single-stage, double-acting, dry-cylinder machines fitted with gas proofed auto-governors and unloading equipment. They have carbon piston rings and carbon glands on piston rods, and can deliver about 400 cubic feet per minute at a delivery pressure of 50 psig.

For recovery of solvent from the oxidizer off-gas, the plant has four vessels packed with activated carbon. Two of them are on line at any one time while the others are being reactivated by steaming.

The plant is controlled from a central control panel housed in the air-conditioned services block. The graphic panel, uses miniature instruments. Because of the inflammable nature of the liquids and vapors in the plant, pneumatic instruments have been used wherever possible.

Delhi-Taylor's New Solvent Plant Ready at Corpus

Delhi-Taylor Oil Corp. has completed construction of a new solvent plant at Corpus Christi, Texas. The unit will provide a greater degree of control and flexibility for the production of narrow distillation range solvents. It will also permit closer control of feed stocks. The 2,500-bpud plant will at first produce heavy aromatic, aliphatic, and various other solvents. When storage and handling facilities for additional products have ben completed the company plans to expand the unit.



National Gas Liquids Corp. plans to build a 20,000-bpd refinery in Orange County, Texas. Orange County Navigation and Port District will provide a 92-

19,000 B/D COKER ON STREAM FOR MOBIL OIL CO.*

*A Division of Socony Mobil Oil Company, Inc.

unit feeds mixture of 7 stocks including Furfural Extract, Duosol Tar and Propane Deasphalting Tar

The new 19,000 B/D Delayed Coking Unit – designed, engineered and constructed by The Lummus Company for Mobil Oil Company at their Paulsboro, New Jersey refinery – is on its initial run.

The coker, comprising 4 coke drums 19 feet in diameter by 63 feet tangent to tangent, is designed for 764 tons per day of coke, making it the largest initial capacity coker ever built in the United States.

The feedstocks are various reduced crudes or blends of residua whose gravity varies from 3 to 14° A.P.I. These charge stocks may be blended with up to 25% of furfural extract.

The unit cokes the heavy residual stocks withdrawn from other refinery units which previously were blended into fuel oil. The coker makes seven products: fuel gas, butane-butylenes, light and heavy gasolines, light and heavy gas oils, and coke.

In addition to the coking section, the unit includes: a gas recovery section, sulfuric acid treater for gasoline, amine treater for light hydrocarbons, and a caustic treater for the butane-butylene stream.

* * *

The Mobil Oil Coker is the 13th delayed coking unit engineered and constructed by Lummus. Lummus has built over 40% of the total delayed coking capacity erected in the last 10 years in the U.S.

When you plan a new unit – or a complete refinery – Lummus can put over 50 years of experience, on more than 800 plants throughout the world. to work for you.

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Building . . .

acre plant site and foundations for refinery units. National Gas will put up $6.5 million worth of processing equipment for high-octane gasoline, which will be the plant's main product. Construction is to start this month and be completed in October, 1960, if National Gas and the Port District sign a lease which is pending.

Maruzen Oil Co. has reportedly borrowed $7 million from Union Oil Co. of Calif. to expand its refining facilities in Japan. California Texas Oil Co., in a similar move, is said to be planning a $5.5-million investment in Japanese petroleum projects.

Sunray Mid-Continent Oil Co.'s Criner natural gasoline plant in McClain County, Okla., is nearing completion. The 5-MMcf-per-day plant will produce 32,000 gallons per day of propane, butane and natural gasoline, and this capacity is soon to be doubled.

Kuwait Oil Co. has completed a new platinum catalyst reforming and catalytic hydrodesulfurizing unit at its Minaal Ahmadi refinery. The unit can process 4,000 bpd of charge stock (a naphtha fraction prepared from straight-run gasoline derived from Kuwait crude oil), desulfurizing and up-grading it to produce a high octane product. This is blended with other gasolines produced in the refinery to yield a premium-grade fuel.

New 20,000-bpd Canadian plant produces gasoline, LPG and other fuels.

Cities Service Completes Its $27-Million Refinery in Trafalgar Township, Toronto

Canada's newest refinery, built by Cities Service Co., was opened recently in Trafalgar Township, 30 miles west of Toronto. The $27-million plant is part of a $40-million Cities Service expansion program underway in Ontario and Quebec. It has a 20,000-bpd capacity.

More than $3 million of the refinery's cost went for equipment to make it quiet and pollution-free.

Primarily a gasoline refinery, the Trafalgar Refinery also will produce furnace fuels, bunker and diesel fuels, truck and railway fuels, and LPG.

The highly integrated plant is arranged so that major refining steps—the catalytic cracking unit, distillation equipment and gas recovery and refining units—are clustered around a single central control room. In this "brain" of the refinery, six men can direct operations.

The Trafalgar Refinery has 11 major buildings and 19 smaller ones, including a large refinery office building.

Storage capacity is equal to 53 million gallons of finished petroleum products—enough to fill the gas tanks of three and a half million motorists parked bumper-to-bumper and three abreast all the way across Canada to Vancouver, says the company.

Among the plant's features is a highly advanced industrial water purification plant—one that will return water to Lake Ontario purer than when it was removed. Illustrating the efficiency of the water treatment system and other controls preventing water or air pollution, the company has constructed an ultra-modern "show window" building at the refinery, housing one of Canada's largest acquariums. In the 4,200-gallon aquarium, native Great Lakes fish thrive in purified water that has been used in the refining process.

The refinery was designed and engineered by C F Braun & Co. working closely with Cities Service engineers.

Standard Oil Co. of Calif. has completed its $33-million answer to the West Coast's growing demand for light petroleum products. A new 55,000-bpd fluid catalytic cracking unit, built in less than a year and designed to convert heavier stocks of petroleum into motor gasoline and aviation fuels, occupies 12 acres at Standard's Western Operations, Inc., Richmond refinery.

Almost half of the plant expenditure was for the cat cracker, and the balance was for a sulfuric-acid alkylation plant, isomerization plant, and off-pot facilities. The cat cracker, a duplicate of the El Segundo unit recently constructed, consists of a large reactor where hot oil feed is contacted with catalyst, and a regenerator section. It includes a CO boiler with a capacity of 300,000 pounds per hour of 850-pound-pressure steam. CO produced during regeneration of the catalyst is burned under the boiler along with other fuels to produce steam for the process. Major plants in the project were constructed by The Fluor Corp.

Sogemines, Ltd. is planning construction of a $17-million synthetic nitrogen plant at Maitland, Ont., to be completed early in 1961. Output of the unit, which will be 100 miles upstream from Montreal on the St. Lawrence River, will include ammonium nitrate, nitrogen solutions, anhydrous ammonia and hydrogen. Sogemines is affiliated with Societe Generale de Belgique, Brussels.

South Hampton Refinery is operating what Universal Oil Products Co. says is the first small size commercial Penex unit. Designed to process 255 bpsd, it is very small compared with earlier Penex installations, and is operating efficiently. The South Hampton unit is converting low octane normal pentane into isopentane for use as a blending component, and operates in conjunction with a previously installed Platforming unit. Construction and operating economies were realized by using the Platformer's high pressure separator, gas recycle and cooler for both the Penex unit and Platformer.

Tennessee Eastman Co. plans to construct a high-purity hydrogen plant at Kingsport, Tenn. The 900,000-cubic-feet-per-day installation will be engineered and equipped by Girdler Construction Division of Chemetron Corp. Scheduled for completion in late 1959 or early 1960, the plant will use the steam-hydrocarbon process for production of hydrogen from natural gas, starting with a hydrogen reformer furnace that converts natural gas to hydrogen, carbon monoxide, and carbon dioxide. This is followed by a "purification train" that includes carbon monoxide conversion, carbon dioxide removal, and a methanator unit.

VEB Leuna-Werk, formerly one of the key plants of I. G. Farbenindustrie, is planing a large expansion which will raise capacity of its 300,000-ton-per-year nitrogen plant about one third. Urea capacity will also be upped, and ammonium-sulfate nitrate added to the firm's products. A medium-pressure process will

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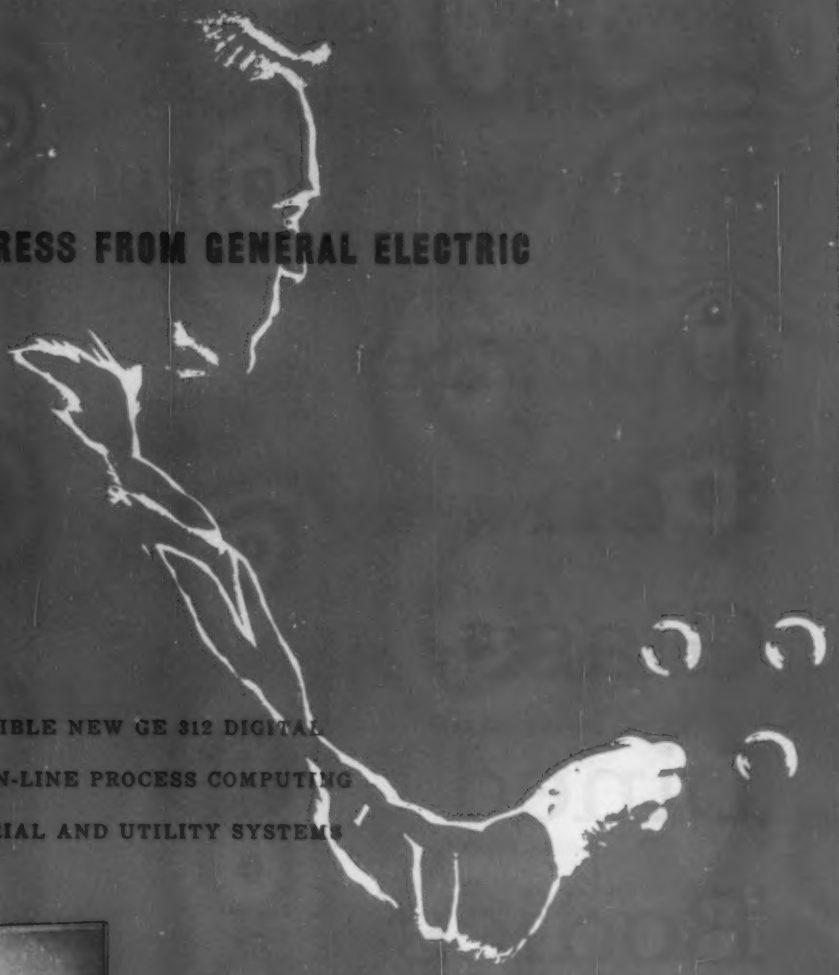

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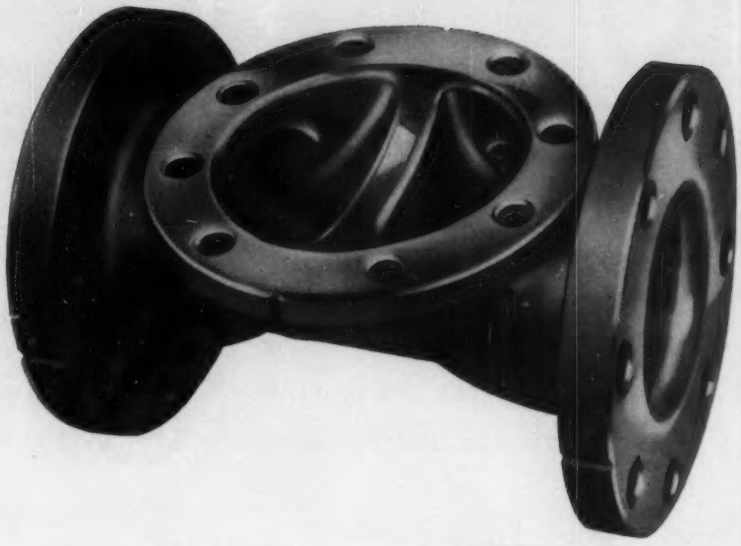
CPA-10 (5-60)

Now...you can have Grinnell-Saunders Diaphragm Valves of

Ductile Iron with Glass-Lined Bodies



After long research, Grinnell has available top quality, corrosion-resistant glass lined bodies for its line of rugged ductile iron valves.

EXTRA TOUGHNESS The greater toughness of ductiie iron resists impact, torsion, line strains and thermal shock. Grinnell-Saunders valves of ductile iron handle severe service requirements where both internal and external impact shocks may be expected, and where piping stresses from rapid heating and cooling occur.

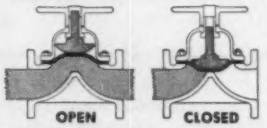
ECONOMY Approved and used by leading industries, ductile iron offers many of the benefits of cast steel at a lower price.

Of particular importance to users of Grinnell-Saunders valves is that ductile iron bodies can now be *glass-lined*—a procedure not practical with cast steel bodies.

WIDE SELECTION Body linings: glass, rubber, neoprene. Diaphragms: soft natural rubber, natural rubber, white synthetic rubber, neoprene, reinforced neoprene, butyl, Hycar, Teflon, Kel-F, PVC (polyvinyl chloride), polyethylene. Bonnet materials: ductile iron, grey iron. Bonnet styles: handwheel (non-indicating stem or indicating stem), chain wheel, lever for quick operation, and sliding stem for a wide selection of power operated topworks.

Important features of the Grinnell-Saunders Diaphragm Valve

- Diaphragm completely isolates operating mechanism from the fluid in the line
- Diaphragm lifts high for full, streamline flow in either direction
- Diaphragm effects positive, leak-tight closure
- Diaphragm easily replaced without removing valve body from the line



GRINNELL-SAUNDERS DIAPHRAGM VALVES

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
industrial supplies • Grinnell automatic sprinkler fire protection systems • Amco air conditioning systems

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Building . . .

be used in the hydrogenation units in place of the high-pressure type used at present. This will save hydrogen, and higher capacity synthesis units will be employed. The plant will also use more automation, and in many cases batch processes will be continuous. Improvements will also include fluid-system catalysts.

Aurora Gasoline Co. is adding a naphtha catalytic hydrodesulfurization unit to clean up the charge stock to an existing catalytic reformer unit with aromatic extraction at its Detroit refinery. Designed for an initial capacity of 8,000 bpd, the unit is sized for an ultimate capacity of 12,000 bpd. Construction was started early in July by The Refinery Engineering Co., and completion is scheduled for late November. Treco is also installing a sulfuric acid alkylation unit at the plant, with completion scheduled for mid-October. Initial capacity of the unit is 2,000 bpd, with ultimate capacity set at about 3,700 bpd. The alkylation unit will use a Treco process.

Sun Oil Co. has begun construction of a $2-million unit to produce propylene at its Marcus Hook refinery. Scheduled to go on stream by the end of 1959, it is designed to produce 120 million pounds of propylene a year with a purity of 99 percent.

The product will be produced by simple fractionation of propane, ethane and butane from catalytic cracking plants and gas stabilization units. Two distillation towers, with a combined total of 140 fractionating trays, will be the new unit's major equipment.

American Chemical Corp. will become Southern California's newest petrochemical producer early next year when the first of four completely integrated units goes on stream at the company's Watson, Calif., plant site. American Chemical will manufacture ethyl chloride, ethylene dichloride, vinyl chloride monomer, and PVC resins at the $7.5-million installation. Three of the four plant units have been under construction since May by C F Braun and Co., the prime contractor. Richfield Oil Corp. and Stauffer Chemical Co. are providing basic raw materials for American's new operation.

Union Oil Co. of Calif. has begun a $17-million refining program to improve gasoline and mid-barrel products at its Los Angeles refinery. Construction will begin shortly and new facilities are expected to be in operation within 15 months. Among the facilities to be built are:

- A 14,000-bpd catalytic reformer to produce a high octane gasoline blending component;
- A 17,400-bpd Unifiner to pre-treat the feedstock to the new catalytic reformer;
- 4,000-bpd Unifiner to upgrade heavy catalytic cracked gasoline stock by reducing sulfur, olefin, and nitrogen con-

HAYS LOW RANGE OXYGEN ANALYZER

- for extremely low O_2 ranges (0 to 1%, 0 to 2%, 0 to 3%)
- not affected by H_2 concentrations up to 50%
- accurate to ±2% of range
- sensitive to changes of .01% oxygen
- no moving parts to wear out or break down

Now, Hays—leader in oxygen analysis—brings you a new analyzer specifically developed for measurement of low concentrations of oxygen.

The Model 632 utilizes a new concept of the principle upon which the Hays Magno-Therm Oxygen Analyzer operates—an instrument that has established an enviable record for accuracy and dependability in thousands of industrial applications over a 10 year period. This basic principle is, that oxygen and a few other relatively uncommon gases are paramagnetic . . . i.e., attracted by a magnetic field. This paramagnetic characteristic of oxygen provides an ideal basis for determining oxygen content of gaseous mixtures.

The Hays Model 632 Analyzer incorporates a basic Wheatstone resistance bridge circuit within a recorder to provide a continuous record of Oxygen content by measuring variations in the paramagnetic properties of the sample gas. Complete details of its construction and method of operation will be forwarded on request.

When used with a Hays Model 771 Universal Electronic Recorder and a suitable sampling system, the new Model 632 Oxygen Analyzer provides these distinct advantages:

- Uneffected by hydrogen concentration up to 50%
- Sensitive to changes of .01% oxygen
- Zero stability within ±1% of range
- No moving parts to wear out or break down
- Three available ranges—0 to 1%; 0 to 2%; 0 to 3%
- Divided flow assemblies significantly reduces possibility of cell damage due to dirty or wet sample gases passing through analyzer
- Accuracy better than ±2% of range
- Extremely fast response to fluctuation in oxygen content

Write today for complete information. Ask for Bulletin B632.

Automatic Combustion Control
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Veriflow Meters and Veritrol
Gas Analyzers • Draft Gages
Combustion Test Sets
Electronic Oxygen Recorders
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THE hays CORPORATION

MICHIGAN CITY 10, INDIANA

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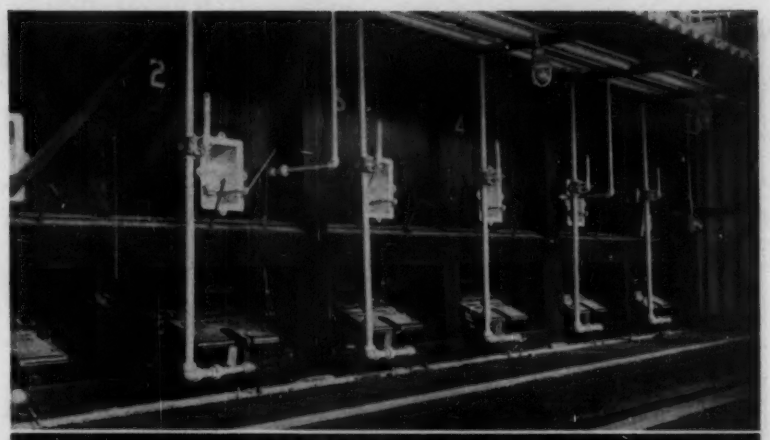

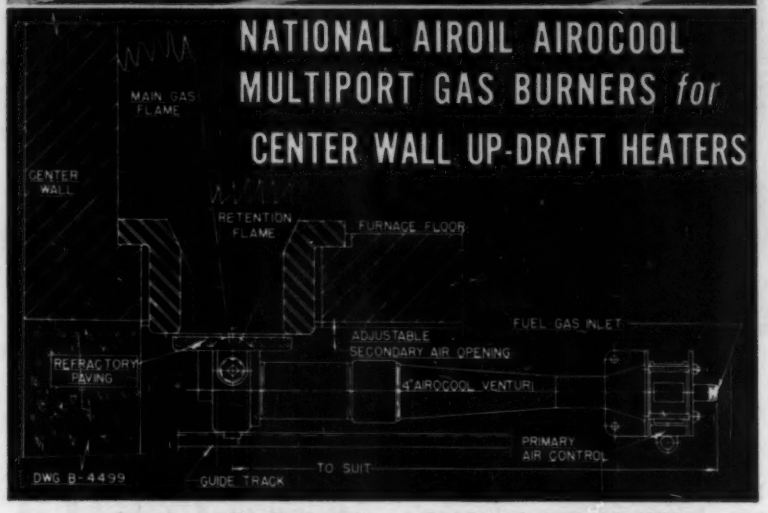

. . . were especially designed and developed for angled firing vertically in all types of radiating wall furnaces-heaters . . . They are not an improvization.

AIROCOOL MULTIPORT INCLINED GAS BURNERS HAVE:

- **Nozzles that can be machined to direct the flame impact at 15°, or any other desired angle to produce the highest degree of heat transfer by radiation from the incandescent reflecting wall. They produce a short flame.**
- **An accurate secondary air adjustment to allow close limits of any excess air and thus result in the highest fuel efficiency.**
- **Higher B.T.U. capacity and greater turn down ratio, with only scant furnace draft and with a minimum of secondary air.**
- **Unique design features that enables them to burn high Hydrogen gas without "flash back"**
- **A reduced size and weight of refractory burner block of inexpensive design.**
- **Means for easily and quickly withdrawing or inserting the gas burner, and requiring only a minimum of labor to accomplish it.**
- **A low maintenance factor including that of the nozzle which is heat protected on its upper surface.**

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BURNER COMPANY, INC.
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Building . . .

tent and by improving its octane rating;

- A 10,000-bpd diesel Unifiner to remove nitrogen and sulfur compounds and improve color stability and cetane of part of the mid-barrel production.

The company also plans to construct a $1.5-million carbon monoxide boiler to reduce carbon monoxide emitted to the atmosphere.

Carstairs Operators' Committee. Calgary, Alb., has awarded The Fluor Corp. of Canada, Ltd., a $3.5-million contract to engineer and construct a gas processing plant near Carstairs, about 40 miles north of Calgary. A grass roots installation, the plant will process 66 MMcf of gas per stream day. Its product recovery unit will remove about 115,000 gallons of liquid hydrocarbons from the gas stream each day. Construction will begin this month, and completion is scheduled for early next year.

Stauffer Chemical Co. has named The Refinery Enginering Co. to design, engineer and construct a skid-mounted methane purification plant at its LeMoyne, Ala., chemical plant. The plant, employing a low-temperature absorption process and low molecular-weight lean oil, will have a daily capacity of several million standard cubic feet. It will separate propane and heavier hydrocarbons from a pipeline gas stream to obtain a relatively pure methane stream. Treco will construct the plant in Tulsa and ship it to LeMoyne.

Gulf Oil Corp. has completed its 30-million-gallon-per-year benzene plant at the company's Port Arthur refinery. The modern plant also produces substantial amounts of toluene, using feedstocks from Port Arthur refinery streams. The plant consists of a catalytic reformer and a purification unit. A platinum catalyst converts the hexane-rich stream to a mixture rich in benzene. This mixture is then solvent extracted and distilled to produce pure benzene.

Phillips Chemical Co. is adding a multi-purpose chemical unit to its Philtex plant near Borger, Texas. The new unit will enable Phillips to upgrade further some of the hydrocarbon feedstocks it produces in the area. It will consist of several facilities, operations of which may be combined to produce small-volume specialty chemicals. The unit also can make new Phillips products in sufficient quantities to test markets before full-scale plants are authorized. Completion of construction is expected in November, 1959.

Amoco Chemicals Corp. plans to construct high-impact and conventional polystyrene plants at Joliet, Ill. Construction of both large-scale commercial and product-development plants will be started simultaneously late this Summer, and the commercial unit is to be completed by the third quarter of 1961. Product development facilities are expected to be in operation by the second quarter of

Where do you fit

in the changing petroleum picture?

records show that 294 refiners have tripled average production—but 160 have succumbed to competition

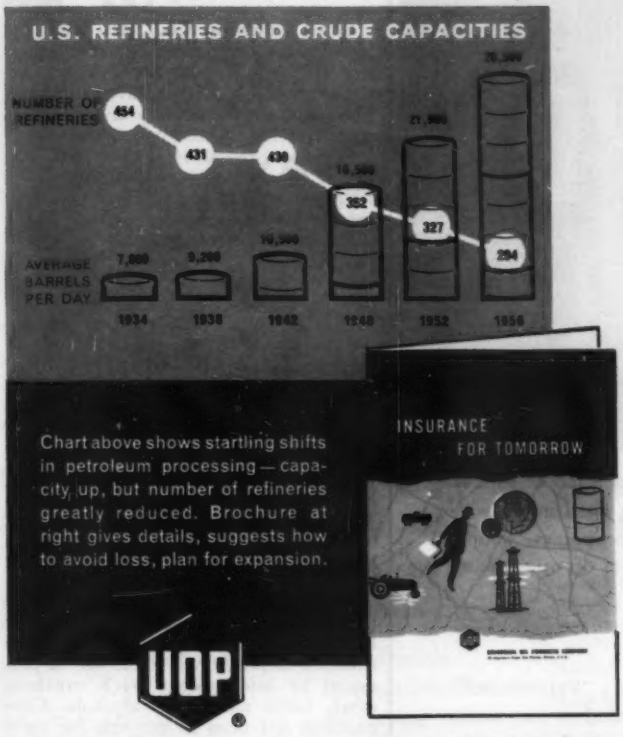

Chart above shows startling shifts in petroleum processing—capacity up, but number of refineries greatly reduced. Brochure at right gives details, suggests how to avoid loss, plan for expansion.

Drastic changes in transportation by road, rail, water and air constantly keep petroleum refiners on their toes. Adding to the complexity of the petroleum refiner's problem are never-ceasing changes in the nature and location of his crude supplies, and of markets for his products.

In this situation there are certain things the refiner can do to avoid losses and capitalize existing opportunities—to utilize his facilities and market potentials to the fullest.

As an aid to intelligent planning, the Economic & Market Research Department of Universal has prepared a bulletin entitled, "Insurance for Tomorrow." It shows how Universal can help coordinate the application of processes to achieve the most economic operation. Send for your copy today. Just fill out and mail the coupon.

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More Than Forty Years Of Leadership In Petroleum Refining Technology

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Avondale

U. S. RUBBER LINING FOR INDUSTRY

(Left) Muriatic acid tank car being prepared for patch job of rubber lining. (Center foreground) Flanged 16" pipe being lined inside with ¼" natural hard rubber with chlorine resistance properties. (Right) Dredge pipes, 40" in diameter, to be lined inside with abrasive resistant and oil resistant neoprene.

Avondale now markets and installs U. S. Rubber's "Permobond" Tank Lining . . . a new service to industry. Included in this work are rubber lining process equipment, shafts, miscellaneous weldments, pipe and fittings. A complete vulcanizing plant has been provided with all-new equipment, including a 6′ I.D. x 40′ long steam vulcanizer (center background above). Let Avondale solve your corrosion problems . . . starting today.

AVONDALE
MARINE WAYS, INC.
VERSATILE BUILDER ON THE MISSISSIPPI
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Building . . .

1960 and will produce a variety of polymers. Following commercial plant completion, product-development facilities will continue to be operated for further product improvement. Plant operation will be based on a Standard Oil Co. (Indiana) process.

Phillips Chemical Co. plans to up ethylene capacity at its Sweeny, Texas, plant by 75 million pounds a year. The expansion will raise production to 255 million pounds when completed late this year. The entire plant is built so that additional expansion can be made readily. Production will go to the company's chemical manufacturing site on the Houston Ship Channel where part of it will be used to make polyethylene. Butane and propane raw materials for the plant come from the parent company's adjacent Sweeny refinery and natural-gas-liquids processing facilities.

Shell Refining Co., Ltd. has completed a new crude distillation unit, engineered and built by Stone & Webster Engineering, Ltd., Shell Haven, England. This unit almost doubles the refinery's capacity. The 80,000-bpd plant brings total refinery output to 160,000 bpd. Two special features of the $18-million plant, designed by S & W and Shell technologists in Holland, are the high degree of heat recovery, resulting in about 30 percent lower fuel consumption than in previous designs, and the good recovery of light hydrocarbons. This is obtained by use of a large high-speed centrifugal compressor which receives all the uncondensed streams and delivers them to the gas fractioning columns.

The Dow Badische Chemical Co. plans to produce acrylic acid and methyl, ethyl, butyl and other acrylic esters at a plant under construction near Freeport, Texas. Production is expected to begin next January, following completion of the plant in December. Acrylic acid will be manufactured as a 94 percent technical grade. The process involved was developed by Badische and is believed by the company to be new to the U. S. chemical scene. Acrylic esters will be produced by esterification with methyl, ethyl, butyl and other alcohols. Construction has been in progress for eight months at a site adjacent to The Dow Chemical Co.'s Texas Division. The $6-million company is owned jointly by Dow and BASF Overzee, N. V., a subsidiary of Badische Anilin-& Soda-Fabrik AG of Ludwigshafen a. Rhein, Germany.

The Arabian American Oil Co. is constructing a $5.3-million plant at Ras Tanura to make sizable quantities of refrigerated LPG. The new plant is scheduled for completion in August, 1960. It will cool the gas to —25 F to permit shipment as a liquid in refrigerated LPG tankers. The 4,000-bpd plant will be the "first in the world" to make refrigerated LPG available for tanker shipment. New facilities will include two 80,000-barrel

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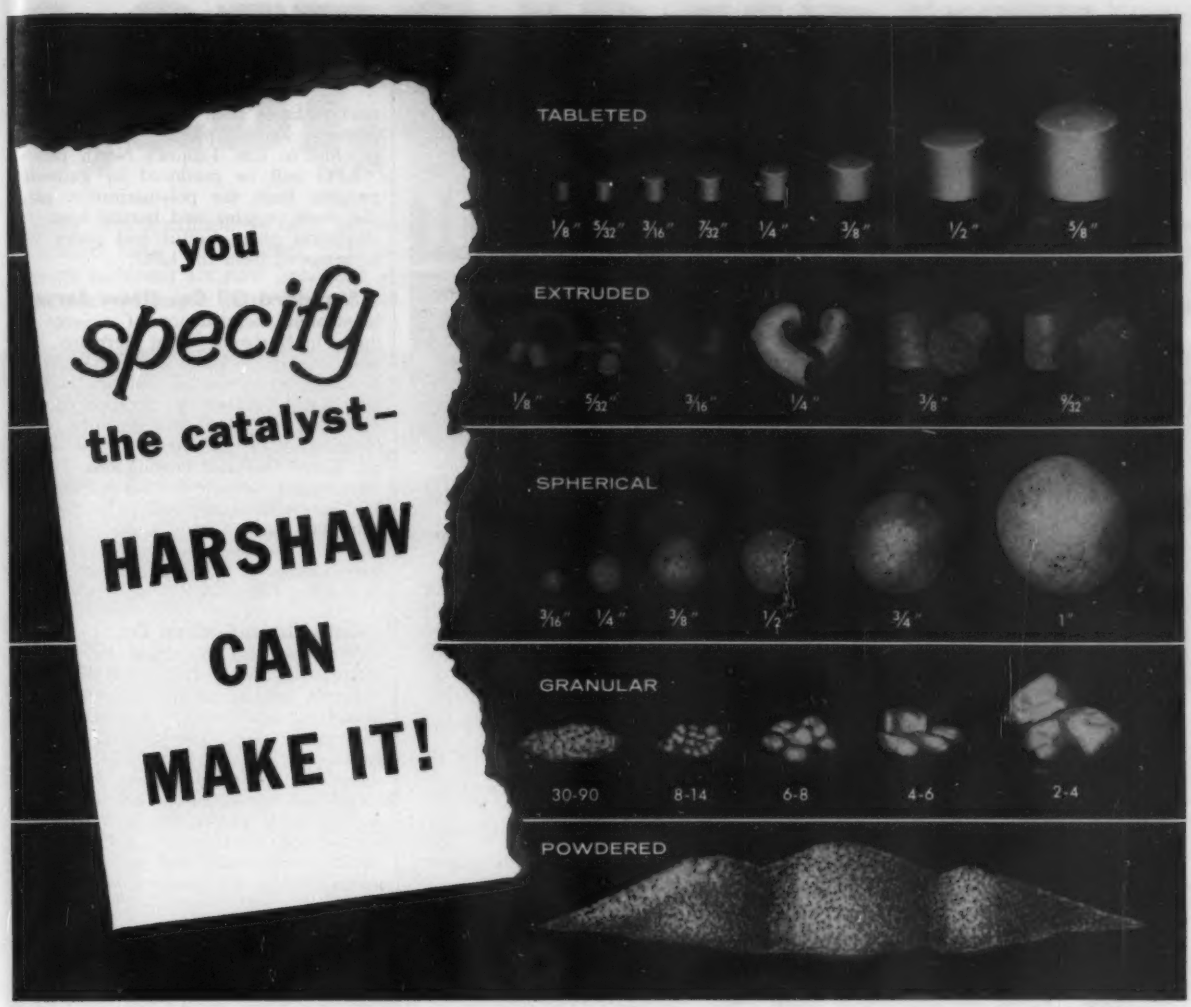

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Aluminum Nitrate — Cobalt Nitrate
Copper Nitrate — Manganese Nitrate Solution
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Nickel Carbonate — Nickel Formate — Nickel Nitrate
Nickel Sulfate — Sodium Methoxide — Zinc Nitrate

Our experienced technical staff will assist you in developing the best and most economical catalyst. If you have a catalytic process in the development or production stage, a discussion with us may prove beneficial.

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Cut maintenance time—increase time on stream

Airetool maintenance tools get tubular equipment back on the job fast

The efficient design of Airetool equipment means maintenance crews get more work done in the same time. These tools are power-packed, yet easy and convenient to handle. Operators like to use them. As a result, you get a better job and stepped-up production.

The increased production you can count on when Airetool equipment is on the job means this: Tubular equipment is brought back to peak efficiency faster. You get back on stream faster!

Let an Airetool representative prove that Airetool equipment outproduces all others. He'll gladly arrange an *obligation-free* plant demonstration. Chances are he can show you Airetool equipment that will save you maintenance time and costs.

Airetrol automatic expansion control system
CC-475, condenser and heat exchanger tube cleaner
G-600, 5-roll refinery type tube expander
Series "6000" air-driven ball-bearing cleaner for straight or curved tubes

30 years experience in pneumatic tools

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MANUFACTURING COMPANY
SPRINGFIELD, OHIO

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge
REPRESENTATIVES: in principal cities of U.S.A., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii
CANADIAN PLANT: 37 Spalding Drive, Brantford, Ontario
EUROPEAN PLANT: Vlaardingen, The Netherlands

Building . . .

steel tanks to store LPG at atmospheric pressure, loading pumps, and a 22-inch pipeline to Ras Tanura's North pier.

LPG will be produced by gathering propane from the polymerization plant and both propane and butane from the alkylation plant. Sulfur and water will be removed from the LPG.

Standard Oil Co. (New Jersey) is planning construction of a large refinery in Karlsruhe, West Germany. The new refinery, to be built by Esso A. G., is scheduled for completion late in 1962 and it to be placed in operation on Jan. 1, 1963. The plant will provide South Germany with gasoline, jet fuels, diesel oil, heavy fuel and heating oils. It will be supplied through the South European Pipeline when completed. The pipeline company plans to build a crude oil pipeline from Lavera, near Marseille, France, to refineries at Strasbourg, France, and Karlsruhe, Germany.

Columbian Carbon Co. is planning construction of a $6-million carbon black plant near Milan, Italy, that will provide 60 million pounds of tire-grade blacks per year into the European common market area. The unit, slated to be on stream in early 1961, will turn out three tire grades of carbon, two tread blacks and one carcass black. Two other carbon black plants are being built in Europe—one by Continental Carbon Co. in the Netherlands, and a joint Continental-Phillips Petroleum venture in France.

Eastman Chemical Products, Inc. plans to up capacity for polyethylene production of Texas Eastman Co., Longview, Texas, from 85 million pounds per year to 100 million. Recent additions to the Oxo facilities at Longview have brought the capacity for aldehydes to 125 million pounds annually.

Union Carbide Plastic Co.'s new liquid epoxy resins plant at Marietta, Ohio, has gone on stream. The 15-million-pound-per-year plant will produce epoxies for protective coatings, reinforced plastics, laminating materials, production tools and dies, adhesives, and encapsulation and potting of electronic components.

Naphtachimie, S. A. plans to build a plant for the extraction of butadiene from cracked gases at the Lavera refinery site of Societe Francaise des Petroles BP. In the first stage 6,000 to 7,000 tons per year of butadiene will be produced.

Shell International Petroleum Co. plans to build a 2-million-ton-per-year refinery in New Zealand. The $47.6-million project would be the country's first refinery.

Reichold Chemicals, Inc. plans to build a $4-million maleic anhydrite unit next to its Elizabeth, N. J., plant. The 20-million-pound-per-year plant will use a Reichold process involving catalytic

1,257,643 HP

OF WORTHINGTON TURBINES NOW DRIVING EVERY MAJOR MAKE OF CENTRIFUGAL COMPRESSOR

More than a million hp of Worthington compressor-drive turbines (and this includes only centrifugal compressor-drive turbines) are now operating around the world. This includes the largest petrochemical unit (we build them up to 50,000 hp), and the fastest (15,000 rpm). There's a "priceless extra" in every Worthington high speed turbine that's behind this remarkable acceptance.

To find out what it is, turn the page ▶

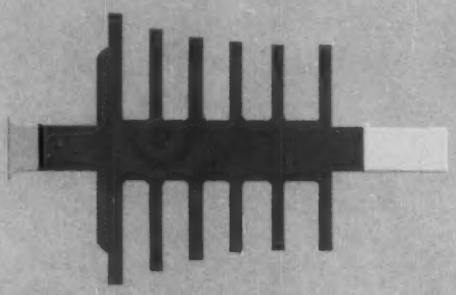
1650 hp., 6783 rpm Worthington turbine driving a Worthington centrifugal compressor at Gulf Oil Corporation's Girard Point Refinery, Philadelphia, Pa.

RELIABILITY

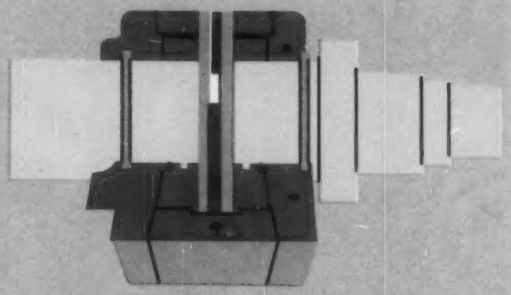
THE PRICELESS EXTRA IN EVERY WORTHINGTON HIGH SPEED TURBINE

Reliability is the ultimate goal of every step that Worthington takes in the design and manufacture of compressor-drive turbines. Reliability is the reason for six extra-quality features shown below. Reliability is the end result of infinite attention to engineering detail based on our 32 years experience in this specialized field. Reliability is the reason Worthington load-tests all multi-stage machines. Reliability is the priceless extra—the single most important reason why more compressor-drive turbines, driving all major makes of compressors, have come from Worthington than any other builder. Worthington Corporation, Wellsville, New York. 48-4

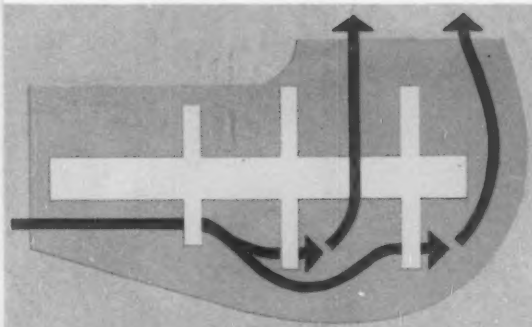
WORTHINGTON



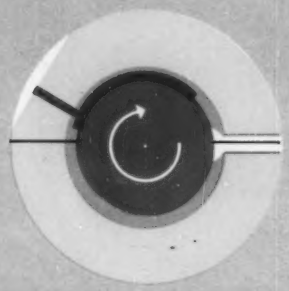
SOLID ROTORS—wheels forged integral with the shaft—provide a more rugged, conservative design.



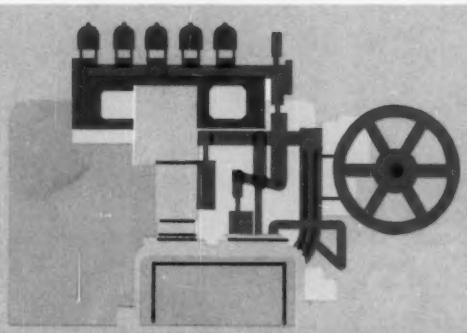
KINGSBURY-TYPE THRUST BEARINGS withstand heavy thrust loads. Shoes pivot, forming a wedge-shaped oil film between thrust collar and bearing surface.



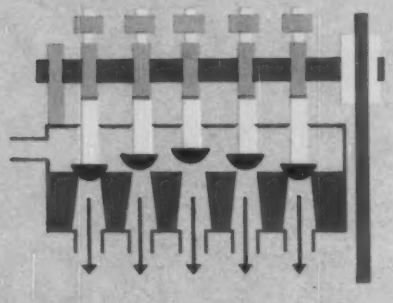
DOUBLE-FLOW EXHAUST—the last stage is divided into two wheels—reduces blade length, increasing efficiency.



ANTI-OIL-WHIP BEARINGS keep vibration to a minimum. An oil dam in upper half of bearing builds up a pressure pad, keeping rotor firmly in place.



SENSITIVE SPEED GOVERNING SYSTEM provides close control over a wide speed range. (Governor takes air impulses from an outside controller to vary speeds.)



CAM-OPERATED AUTOMATIC NOZZLE CONTROL. Each valve, with separate cam, controls a group of nozzles for maximum economy at all loads.

Building . . .

oxidation of benzene, azeotropic dehydration, and direct condensation from the gas stream. Expected to be completed by next June, the unit will be engineered and constructed by Badger Mfg. Co.

British Petroleum Co.'s Dinslaken, Germany, refinery, 15 miles North of Duisburg, has erected the first of two main distillation towers. The second will be installed this month. When the refinery is completed next year the two distillation units will be capable of processing 100,000 bpd. A few smaller towers, part of some of the process units, have already been erected at Dinslaken.

Shamrock Oil & Gas Corp. has awarded The Fluor Corp., Ltd., a contract to engineer and construct an 8,000-bpd fresh fed catalytic cracking unit at its McKee refinery, Sunray, Texas. Engineering of the project has started in the company's Los Angeles office. Construction will begin late this summer, with completion scheduled for next spring.

British Petroleum Australia, Ltd. has completed a $1.4-million lubricating-oil blending plant on the River Yarra at Spotswood, Melbourne, Australia.

The first batch blended was 4,000 gallons of motor oil. A total of 180 different grades and types of lubricants will be blended and packed at the new plant.

Ashland Oil & Refining Co. has completed an aliphatic solvents and specialty jet fuels expansion at its Leach, Ky., plant on the Big Sandy River. The firm has also started up a new gas concentration unit to handle gases from the catalytic cracker.

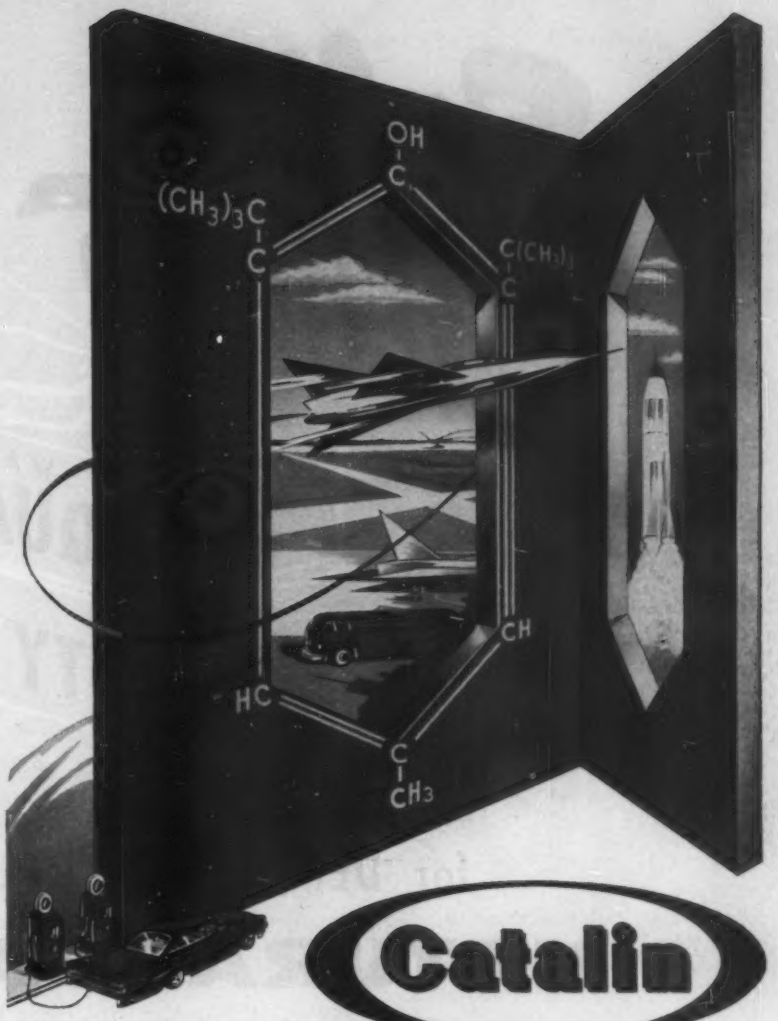
El Paso Natural Gas Co.'s $5.5-million gas plant at Opal, Wyo., has gone on stream. The 267,000-gallon-per-day plant, designed and constructed by Fluor Corp., produces propane, butane and natural gasoline.

Borden Co. plans to construct a 6-million-pound-per-year synthetic resin plant and 7-million-pound-per-year formaldehyde unit in Colombia, S. A. The project is expected to cost $1 million.

National Carbon Co. is planning to construct a $9.5-million organic chemicals and polyethylene resin plant in India, to begin operation in 1960.

Yacimientos Petroliferos Fiscales, Argentina's state-owned oil company, is planning a 6,500-bpd refinery at Aguaray, Salta Province, near the nation's Campo Duran oil fields.

Home Oil, Ltd. will operate, and hold a 50 percent interest in, a new $3.75-million gas processing plant in the Carstairs-field area of Alberta. Other owners of the 75-MMcf plant are Canadian Superior Oil of Calif., Ltd., Tennessee Gas Transmission Co., and Texaco Canada, Ltd. Fluor Corp. of Canada, Ltd. will handle construction.



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antioxidant CAO-1

98.9% PURE* / sets the highest standards for purity and effectiveness

Catalin ANTIOXIDANT CAO-1 . . . the field's finest grade of 2,6-ditertiary-butyl-para-cresol . . . meets U. S. Government military specifications for use in aviation gasolines, turbine and jet fuels. A major advantage achieved with this heat-resistant, water-insoluble antioxidant is that high-octane fuels are effectively protected, with no loss of octane rating. Gum and peroxide formations are inhibited, and deposits in the aircraft intake manifold and engine are markedly reduced.

Catalin ANTIOXIDANT CAO-1 stabilizes high-octane automotive gasolines, as well as turbine, insulating, hydraulic and transformer oils . . . in fact, nearly any petroleum hydrocarbon exposed to oxidizing conditions.

Samples, literature and technical assistance wait upon your request. Inquiries invited.

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One Park Avenue, New York 16, N. Y.

chemicals plastics resins

* Typical Analysis

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Solid Support

for DEPENDABLE DELIVERIES of

NATURAL GASOLINE

whatever the grade, whatever the volume,

WHEN You want it . . .
WHERE You want it . . .
and the WAY You want it!

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Sharpen Your Thinking Habits

It stands to reason that you can't forget something if you never really learned it in the first place. Therefore, practice these techniques of learning in order to develop your power of retention—and remembering

John D. Quinton
Tennessee Gas Transmission Company, Houston

IT SEEMS that everyone would like to improve his memory. Some want to remember the wife's grocery list. Party-goers want to remember the names and faces of those that they "had one for the road with." Preachers, salesmen, and public officials strive constantly to "improve" their memories.

Throughout the busir.ess world men and women are constantly harassed (so they say) by a "poor" memory. Annually, thousands of words are written by, and hundreds of publications are bought from, authors who promise a quick and easy method to "improve your memory in ten easy lessons."

But let's pause for just a moment to take a look at this popular thing called "memory." Let's see just what it is and determine, if possible, if it can be improved.

The word "memory" is a very general term that we use when we really mean remembering, recalling, recognizing and retaining past experiences. It follows, then, that to keep or retain something in our memory, the material will have had to be experienced or "learned" previously. However, if such material has been learned and all of it cannot be remembered then some "forgetting" has occurred. Forgetting, of course, is our failure to retain what we learned. Like memory, forgetting is a part of the process of learning. Therefore, to get some insight into this "memory" subject, we have to consider it in three different phases. These are:

- Learning
- Remembering
- Forgetting

LEARNING

Everything we have stored in our "memory" has come through a continual process of interaction with our environment. The ideas we have, the knowledge we possess, the accumulation of facts and fantasy, come under the heading of the process of learning. Consequently, the first step in improving your memory is to improve the learning process. There are a few methods and techniques of learning that will, if practiced, help you retain whatever it is you want to remember.

But keep in mind that it is impossible to develop an entity called "memory." What you will really be developing are methods and tech-

"If at times you can't remember a person's name after just being introduced, it's because you are trying too hard to make a good impression—you are concentrating only on yourself."

niques of learning that will facilitate retention and the result will be a "better memory."

1. We Remember What We Want To Remember. To learn something we have to "pay attention" to it. When you want to know the time of day, you will be more apt to notice a clock in a nearby service station and miss other subjects such as colors and objects. On the other hand, if you wanted to know the temperature, in searching for the thermometer, your eyes would probably skim right over the clock without even noticing the time. So, if we wish to remember something we must first want to remember it and in the process we must give it our concentrated attention.

As an example, when meeting someone for the first time we must sincerely pay close attention to the name and face if we wish to remember them. Many times we do not remember the name simply because we are trying to make a good "first impression" and our concentration is on ourselves. The stranger's name never makes an impression on the mind and later when we try to remember it we admonish ourselves for "forgetting" the name. But then how can one "forget" a name that was never learned in the first place?

Besides, what better first impression can you make than to remember the stranger's name, face and background? Pay close attention to these and you will learn them, or, in other words, commit them to memory.

Just attending to some facts, such as names and faces is not enough, however. We must also have the *intent to learn* them. There are many things that we read (attend to) but never learn or commit to memory. Don't look now, but after several years of use and many reproductions, can you recall your Social Security number? Now try to recall your armed service serial number. Facts, such as the serial number, that are intentionally learned are much better recalled than the others.

In remembering names and faces it will pay to remember these six simple rules.

First. Insure that the name has been heard correctly, repeat it and, if necessary, spell it. The owner not only can correct you if it is pronounced or spelled incorrectly, but will be pleased that you are interested enough to get it right.

Second. Write it down later if you wish to make a firm neural impression, for we tend to remember things we see better and longer than those we hear.

Third. If, at a business meeting or social gathering, names are mumbled and given too rapidly, take the time later to introduce yourself to those you want to remember, getting their names correctly. If it is inappropriate to seek out each person individually, you can obtain their names from an associate who knows them.

Fourth. It will help if you learn something about the individual's personality. This connection between name and personality will make a lasting impression. Some people feel that it is helpful to connect the name of a stranger in some outlandish way, as Mr. Cypress might remind us of a swamp. Such bizarre and illogical connections are not nearly as effective as a logical connection of name and facts about his personality. Besides, the next time we meet Mr. Cypress we might call him Mr. Swamp.

Fifth. You can remember names better if you say them aloud. Therefore, a name should be repeated in conversation to its owner and others as often as good taste permits. Begin and end sentences with the stranger's name. Not only will you learn his name, but he will learn yours—for, by using his name, you have made a lasting impression in his mind, too.

Sixth. In recalling an individual that you met at Joe's party or some important business meeting, don't think of him as "the fellow who had the facial scar," but rather think of his name.

2. Look for Meaning. Words that we use are merely symbols that represent the original objects. For example, the symbol "apple" has no meaning to a child that has never been shown an apple and instructed that it is an "apple." Only after the child connects the *word* "apple" to the *object* "apple" does the word take on meaning.

In addition, when the child sees an apple for the first time it has no gustatory significance whatsoever. But after he eats an apple, we find that the sight of the apple alone becomes sufficient to cause a flow of saliva—to make his mouth "water." Later the child learns that the symbol "apple" stands for this wonderful object he has been eating and then his mouth "waters" when he hears the word (or symbol) "apple." The symbol now has "meaning." Thus, words become substitute or symbolic stimuli, replacing objects, ideas and actions.

To facilitate learning it is advisable to look for the correct meaning of the material we are reading or hearing. In other words, we must have the same "frame of reference" as the writer or the conversationalist.

You can learn words, ideas, and other material with meaning much easier and remember them much longer than those without meaning. Try this experiment. Look at the following list of words for 15 seconds and try to memorize them. Then cover them up and write them, not necessarily in order, on a piece of paper:

Horse	Barn
Grass	Cow
Oats	Pig
Wagon	Fence
Red	Post

No doubt you remembered all ten of the words. Why? Because they

have meaning to you. Not only does each word have a specific meaning, but they have interrelated meanings. They are all farm words. Now, try this. Look at the following list for 15 seconds and try to reproduce these from memory:

XSP	NDI
AHC	JSF
DZB	MCE
KQY	EOL
WCN	CFR

Wasn't that much more difficult? Material with little or no meaning or organization—such as lists of unrelated items (nonsense syllables, formulas, dates, names, etc.)—is less well remembered and more difficult to understand than material in which there is meaning and organization.

As in the story of the child and the apple, a word has meaning to you according to your past experience with the object which it stands for. However, many times we get the wrong meaning and later our memory fails us or we report the wrong facts.

Think back into your childhood and remember some of your experiences where you misinterpreted "adult" language.

One young boy went to church and heard them sing, "The Old Time Religion." On returning home he requested his parents to buy some pigeons—because the people at the church had said it was "The Only Time For Pigeons."

Another boy heard the phrase, "Gladly, The Cross I'd Bear." When asked what they had sung in Sunday School he replied, "Gladly, the cross-eyed bear."

These are not bizarre examples, but could be duplicated by merely asking your friends for such incidents in their past experience.

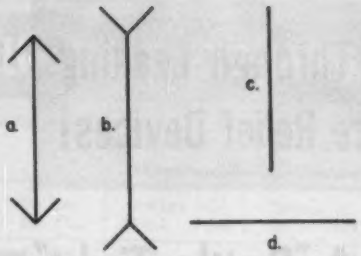

FIGURE 1—Sometimes we don't always see things as they really are.

3. Proper Mental Set. Another important factor in learning is your mental *set*. By this we mean where does your interest lie? What goals do you have in mind? Whatever your interest and his concern at the moment, what you see or hear will be interpreted in relation to that pattern.

If you are not interested in what is being seen or heard there is small chance that it will "impress" you and the end result is no memory of what has happened.

To remember the material, you must consciously fit it into your pattern of thinking and doing.

4. Repeat the Material. Repeating some recently acquired material will enhance both understanding and remembering. As the story goes, a very successful Negro preacher explained his success by explaining that, "First I tells them what I'se goin' to tell them; than I tells them; and then I tells them what I done told them."

Mentally repeating a person's name or address, or an important message will help in committing it to memory.

5. "See" It Correctly. One good question to always ask yourself is, "Do I see it the way he does?" To learn correctly, and hence, to remember correctly, it is imperative that we "see" the subject as it is intended for us to see it. For, in remembering and relating facts, we "tells 'em the way we sees 'em."

For instance, look at the drawings in Figure 1.

As you may readily prove by using a ruler, the lines "a" and "b" are of equal length as are lines "c" and "d." However, lines "b" and "c" *seem* longer. The lines are equal, says a ruler, but we "see," and many times insist, that lines "a" and "d" are shorter. In learning then, we must try to understand the viewpoint of the person presenting the material. We must "see" it the way he "sees" it and wants us to learn it.

Take the drawings in Figure 2 for example. If you are unfamiliar with them you will nevertheless see each of them as resembling something you have seen in your past. What is more significant, you could see them a great number of times without seeing them any other way. The figure on the right might remind you of a telephone; the other a bird bath or vase.

Now look at them from another person's viewpoint and "see" then the way he may have intended for you to see them. If you look rather fixedly at each figure you will find two "faces" looking at each other in the "bird bath" and two "dogs" or "foxes" looking at each other in the "telephone."

Now try to look at the two figures without seeing the "faces" and "dogs." It's very difficult, and almost impossible because you have learned they are there. Later in remembering what you have seen you will recall that at first you were learning the "wrong" material and only after you got the other per-

FIGURE 2—In this illustration some will only "see" a vase or birdbath and an old fashioned telephone.

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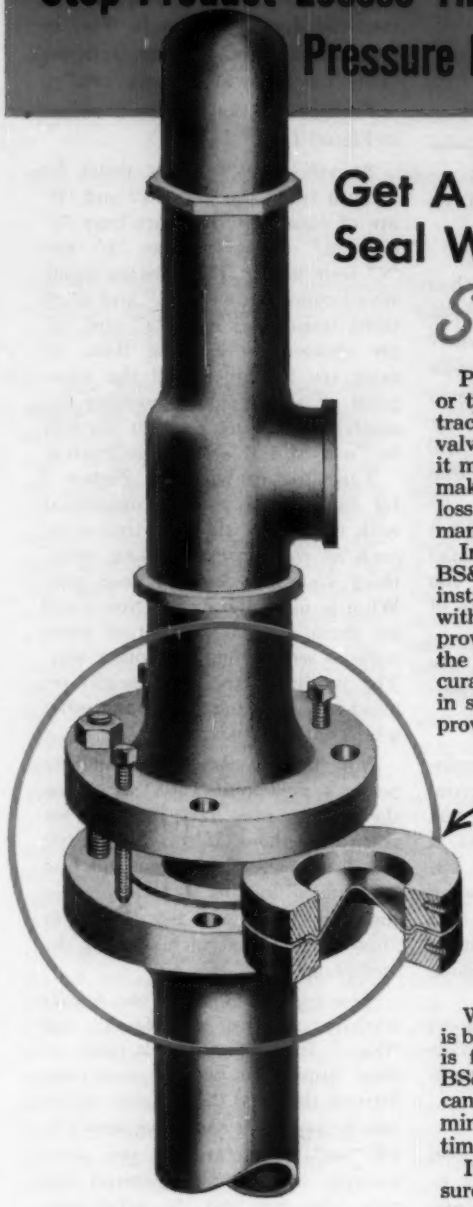

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son's viewpoint did you learn correctly.

Examples of this sort are a great help in developing our understanding of the misunderstandings we have with others and the later "poor" memory.

6. Associate the Material. It makes very little difference in remembering whether the word is tisch, tavola, plateau or table so long as we respond by thinking of the object from which we eat. By the same token, it makes little difference what the stranger's name is if we associate it with him when we hear it. Tie the name in with his features, his dress or some other tangible object. Or try to associate it with something in your experience, for you will soon find that the wider and more diversified your previous experience, the easier it is to learn something new.

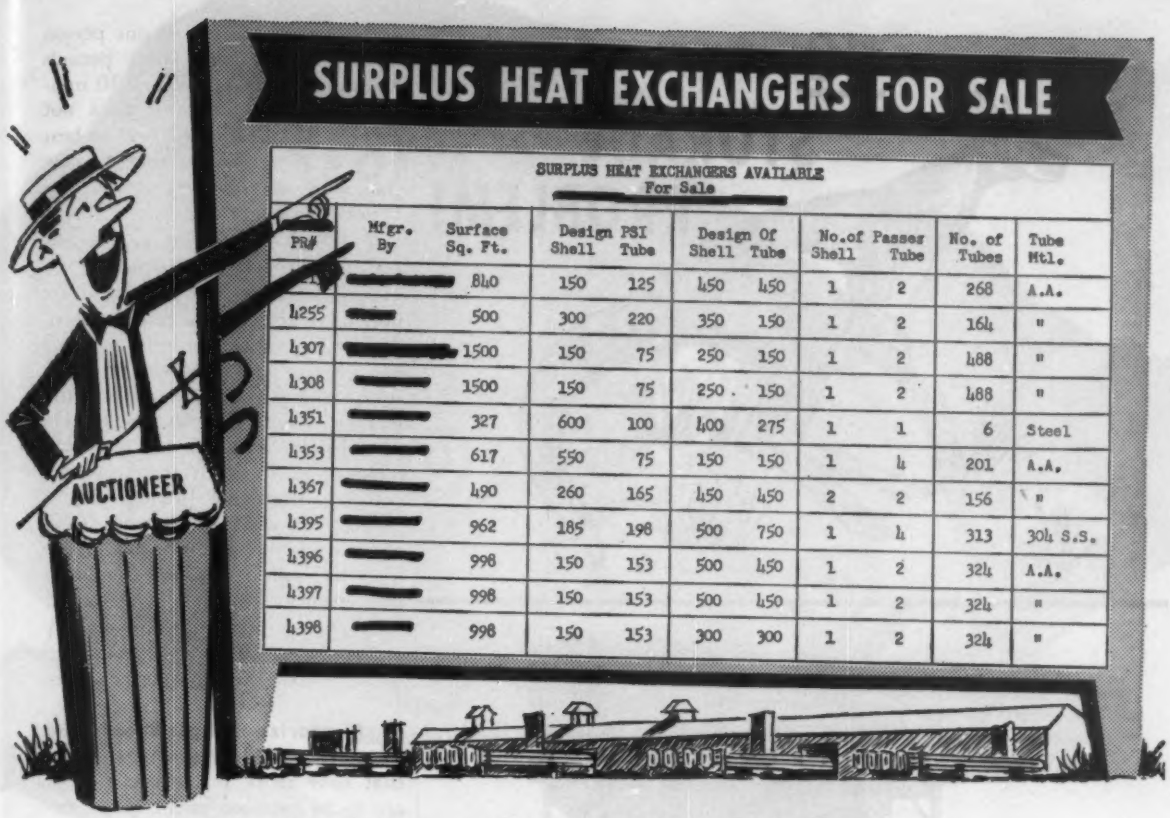
7. Overlearn the Material. If you want to be absolutely sure that you will remember a name, a formula or any other material, then you must "overlearn" it. Overlearning is achieved by studying the material beyond your ability to repeat it perfectly after a few moments of study. For instance, if you can learn a list of words for immediate recital after only six repetitions it may be necessary for you to repeat the list 25 or 30 times to insure remembering it permanently.

Some things that you have overlearned are:

- Your name.
- Birthdate
- Place of birth
- Serial number
- Short poems
- Religious songs

As shown before by the farm words and the nonsense syllables, the number of repetitions for overlearning would depend upon the type of material you want to learn. Remember, though, overlearning does not mean learning more than is necessary; it does mean repeating many times what you have learned so that your retention will be permanent.

8. Distribute Your Efforts. Generally speaking, distributed learning is better than massed learning. However, there is no cut and dried for-



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	[redacted]	840	150	125	450	450	1	2	268	A.A.
4255	[redacted]	500	300	220	350	150	1	2	164	"
4307	[redacted]	1500	150	75	250	150	1	2	488	"
4308	[redacted]	1500	150	75	250	150	1	2	488	"
4351	[redacted]	327	600	100	400	275	1	1	6	Steel
4353	[redacted]	617	550	75	150	150	1	4	201	A.A.
4367	[redacted]	490	260	165	450	450	2	2	156	"
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4396	[redacted]	998	150	153	500	450	1	2	324	A.A.
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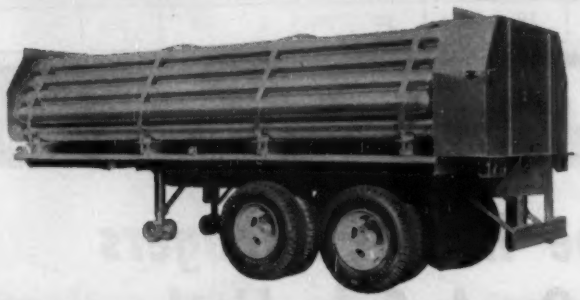

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mula for each person. If one person finds that 20-minute study periods separated by an interval of 10 minutes is best for him, it does not necessarily follow that it will be best for you. Nevertheless, studies show that some sort of distribution is better than none.

There are several reasons why distributed learning is superior to massed learning. First, if the study period is long and concentrated, fatigue sets in, thus interfering with the learning effort. Second, a short study period also motivates the learner. Third, the rest, or inactive period reduces fatigue and improves motivation. In addition, the rest period permits the individual to "mull over" what he has been studying and thereby enhances learning.

Other experiments point out perhaps even a more important factor. Rest periods tend to eliminate any errors of association or learning and thereby strengthen the correct ones.

9. Memorize What Should Be Memorized. There are many things that have to be memorized if they are to be retained at all. Such mechanical details as formulas, conjugations, lists of unrelated items, etc. Such material cannot be just learned by reasoning. Therefore, you'll save a great deal of reasoning time by committing such things to memory by rote memorization which will leave the mind free to concern itself with creative thinking and the larger ideas of the moment.

When memorizing, you must keep two factors in mind. First, do not attempt to memorize large quantities of material at one time. Ten to 15-minute intervals spent in memorizing are quite enough. Attention tends to wander after about 15 minutes and you would be wasting your time.

Second, memorize the material in the form in which you are going to use it. It is difficult to remember material in a sequence other than one in which it was memorized.

To illustrate this point try this experiment: look at the letter square below very closely and memorize it. Do not cover it or stop studying it until you memorize the letters.

K B S
P Y C
N X T

Now cover the letter square and

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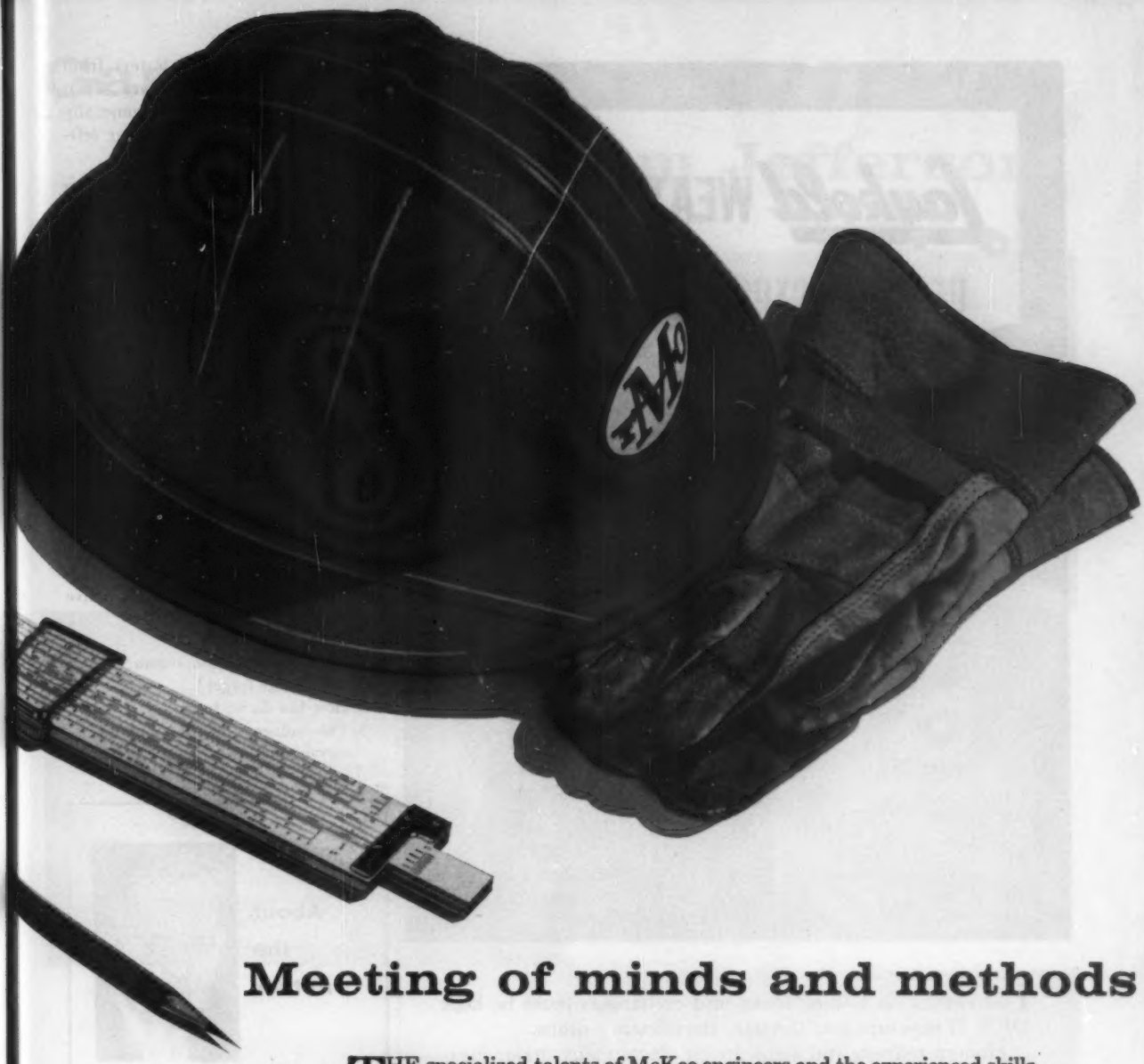

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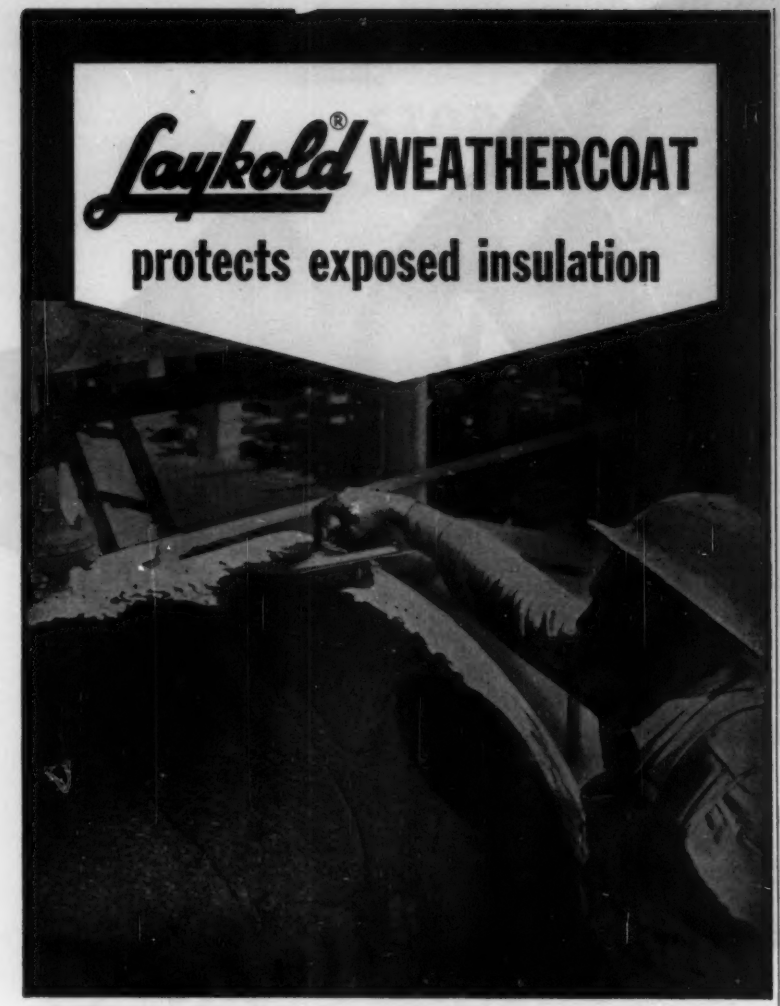

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start remembering the letters from the *lower right-hand corner.* Is it difficult? Yes, because we generally learn material from the upper left-hand corner and line by line.

The processes involved in learning just discussed here are usually considered "laws" of learning. While they are not actually scientific laws that can be depicted in equations, they do clarify the conditions under which learning occurs.

In considering these generalizations or laws, we have, of course, put the emphasis on "acquiring" material. In the next part of this article we will consider the process of "retaining" what you have acquired.

In Part 2, "The Two Processes of 'Memory' " which will appear next month, Mr. Quinton will discuss such highly interesting and informative points as:

1. **How well do you recall?**
2. **What is your memory span?**
3. **Why do we forget?**
4. **How fast do we forget?**
5. **The influence of emotions on remembering.**

About the Author

John D. Quinton is a training representative for Tennessee Gas Transmission Co., Houston, where he develops and presents training programs. Holder of a B.A. degree from Lincoln Memorial University and a M.A. degree from Tulsa University, he also completed two years' work toward a Ph.D. degree at Kansas University. All of Quinton's studies have been in industrial and clinical psychology. He has been a professor at Kansas and Tulsa universities, and has headed the Psychology Department at Arkansas Polytechnic College. Quinton was a consultant for Service Pipe Line Co., Tulsa, for two years, and a training representative for Shell Pipe Line Corp., for four years, before joining Tennessee Gas.

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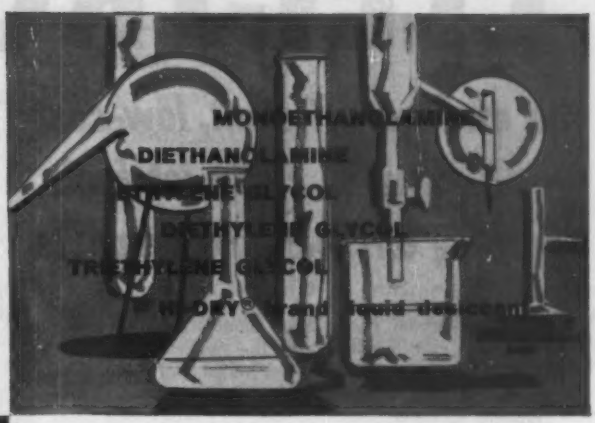

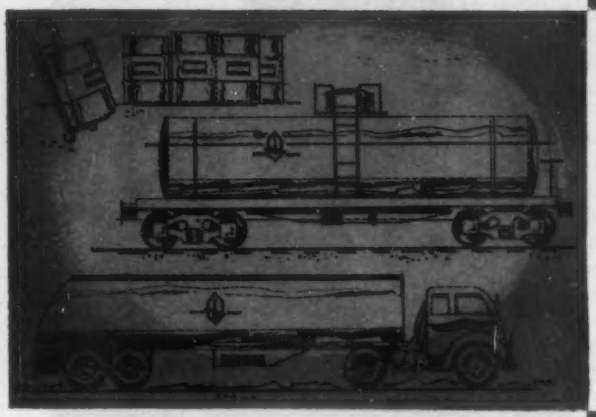

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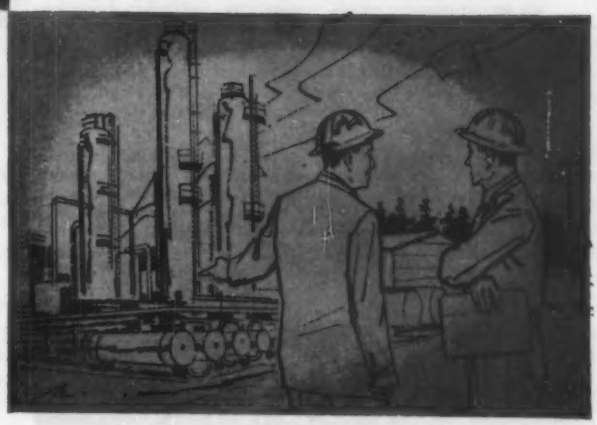

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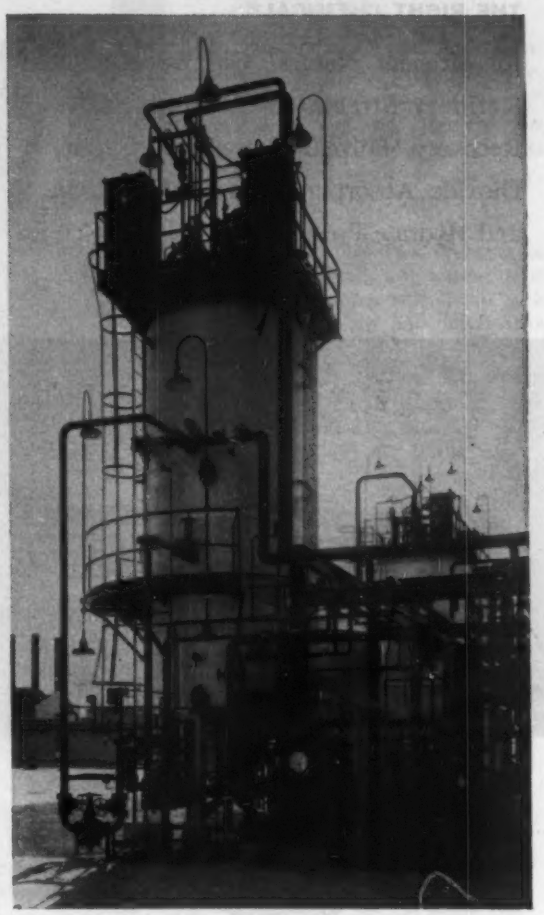

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How to Present a Construction Estimate

Few things are more discouraging than to have your estimate cut-up by a misunderstanding management. It's probably your fault though, so take this sound advice which you'll find plenty helpful the next time you face "Mahogany Row"

William I. McKay
The Fluor Corporation, Ltd., Los Angeles

THE PRESENTATION of cost estimates to management is of great importance in any business. In the engineering-construction field it is of even greater importance, for most estimates are prepared from very preliminary information and the resultant quotations carry many risks.

The ultimate approval of any estimate always lies in the hands of management, and an inarticulate appraisal of the estimate can result in loss of business, or financial loss to the company. Either way you lose.

There is no more discouraging experience for an estimator than to have an estimate representing many hours of effort slaughtered before his eyes due to misunderstandings or misconceptions of the actual conditions by his management. He is, however, the cause of his own dilemma, and rather than curse his management, he should blame himself. He simply did not give them the facts.

Let's consider a hypothetical estimate . . . how should it be presented to Mahogany Row?

All's Ready. Let's say your estimate has been completed. It has been analyzed, compared to other similar projects, checked for reasonableness and arithmetic errors. It has been reviewed in detail with all operating departments. It is now ready for presentation to management.

In preparing this estimate a hundred pounds or more of paper may have been generated. This paper backing up the estimate in detail for every item included. The actual estimate itself may contain a hundred or more pages.

Now, consider that only an hour or perhaps even less time will be allowed to present the estimate to management. Obviously, this allows no time to look at details nor does management wish to look at details. How then, does the estimator emerge from this morass of paper with the significant facts compressed into a small capsule? (Capsule may be an unfortunate word—it is not implied that management is to swallow anything.)

Booklet is the Key. The small eight-page booklet shown on the next two pages allows this compression of detail and brings out the significant information. This booklet is by design a very simple document. The lettering is large; only a few items appear on each page; and it can be read in two or three minutes. Yet, it provides sufficient information so that management having read the booklet can ask the right questions. This facilitates their appraisal and creates the proper climate in which to exercise judgment.

Page 1. This actually is the title sheet and covers such information as the "who," "what," and "where" of the estimate.

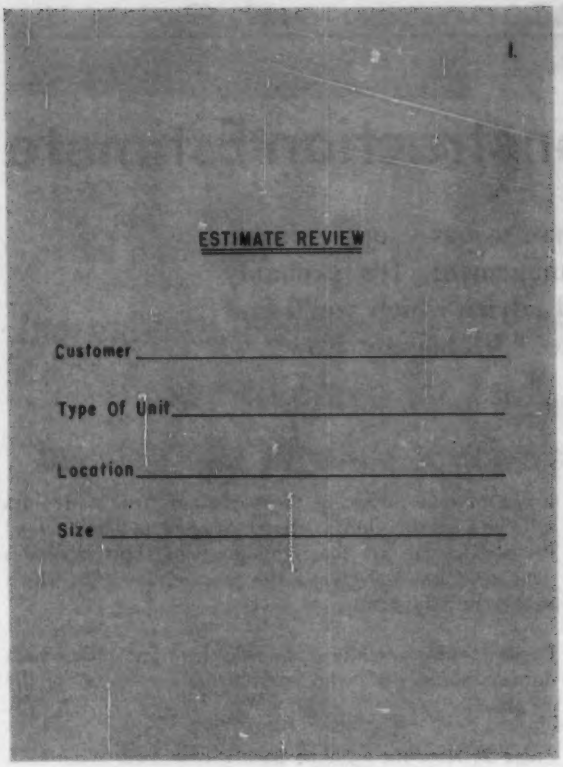
Page 2. Here the estimate itself is described. What kind of estimate . . . what kind of bid is being made . . . how much did the estimate cost and how long did it take to prepare it? These questions are all important.

Accurate estimating requires time and money and management needs to know how much of both were used. Also, on this page the competitors quoting this project are listed. You may not always know this information, but it is quite necessary to evaluate the competition when completing the estimate.

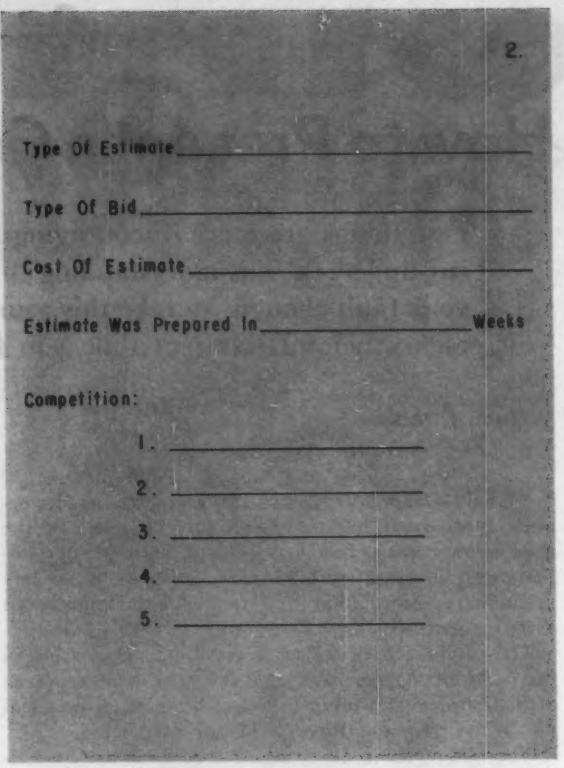
Page 3. This covers three significant points. First, who did the process design? If each contractor is providing his own process design, it projects another rather large variable into the picture. On the other hand, when the customer furnishes the process design this item is constant for all bidders. Next, past experience on units utilizing the same process are tabulated. This helps develop the degree of confidence that should be applied to the etsimate. On the bottom of this page you list any guarantees that are being made with the bid. This points out areas of risk included in the quotation.

Page 4. The over-all schedule is tabulated on Page 4 as well as the "firmness" of the process equipment account. Generally, this account represents about one-third of the total estimate, and is the key to the schedule of the project. If this account is ready to purchase, it implies a firm design and permits rapid movement into the design and construction phases of the work. If it is not ready to purchase, it indicates either a hurried estimate or a vagueness in the process design.

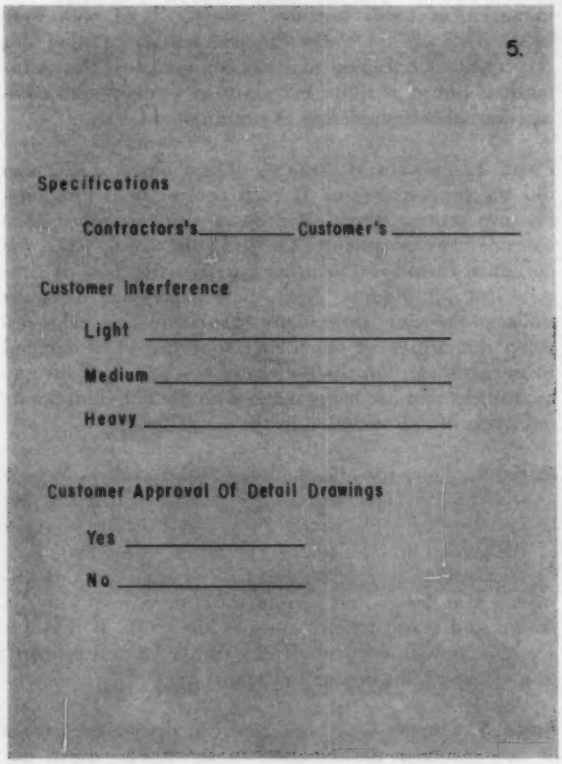
Page 5. On the fifth page, you can discuss the extent of the customer participation in the design. First, are the customer's specifications or the contractor's being



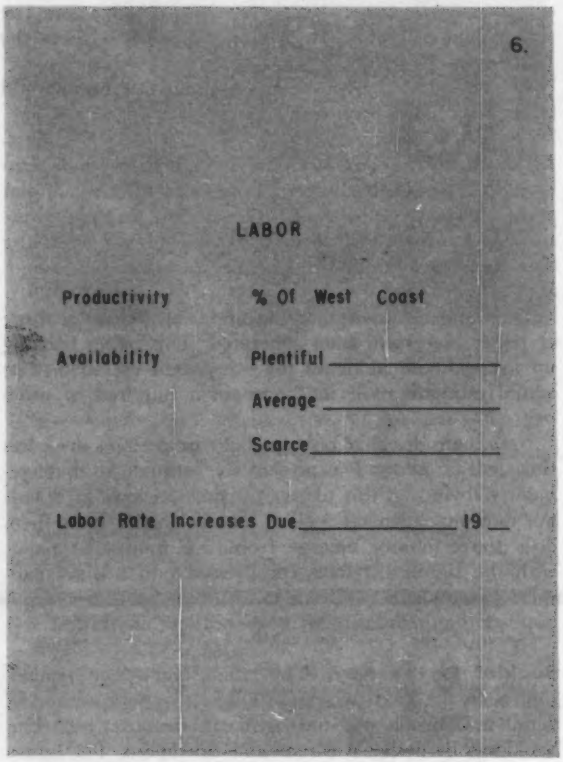
PAGE 1—The title sheet covers basics of the estimate.



PAGE 2—Describes the estimate and lists competitors.



PAGE 5—Extent of customer participation in the design.



PAGE 6—Lists significant facts involving field labor.

3.

Unit Processed By_____

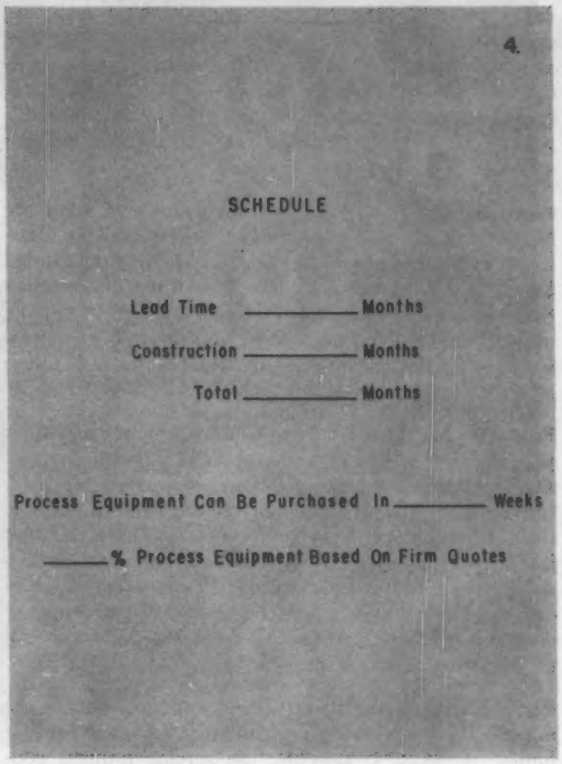
Contractor's Past Experience

Customer	Location	Size	Cost	Year Built

Guarantees:

1. Process Design Yes_____ No_____
2. Utility Consumption Yes_____ No_____
3. Completion Yes_____ No_____
4. Other_____

PAGE 3—Covers process design, experience and guarantees.



4.

SCHEDULE

Lead Time _____ Months

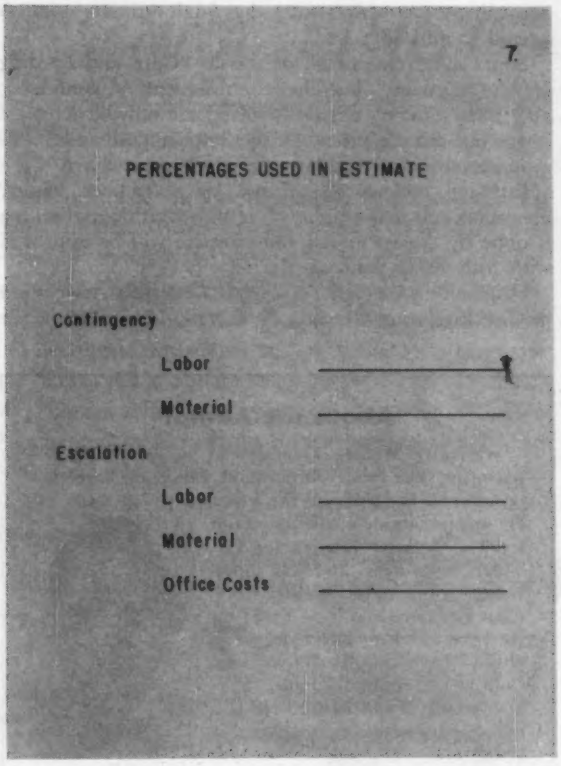
Construction _____ Months

Total _____ Months

Process Equipment Can Be Purchased In _____ Weeks

_____% Process Equipment Based On Firm Quotes

PAGE 4—Tabulates entire schedule and equipment account.



7.

PERCENTAGES USED IN ESTIMATE

Contingency

Labor _____

Material _____

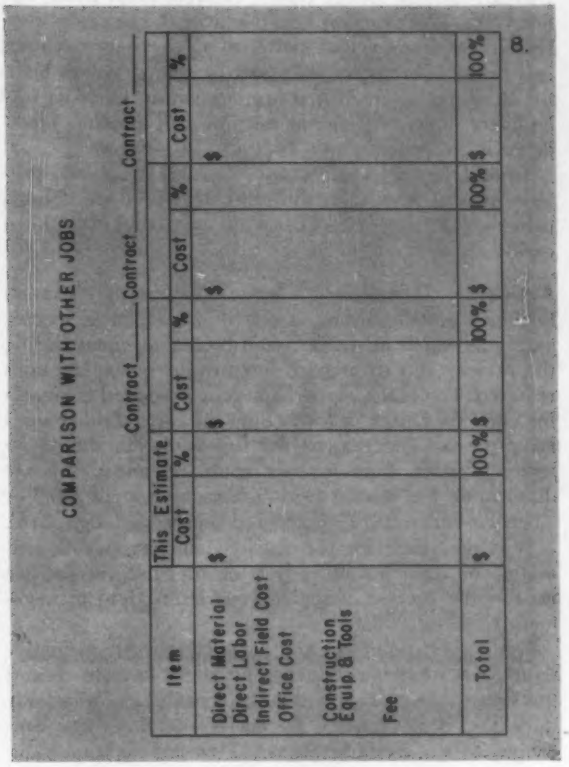
Escalation

Labor _____

Material _____

Office Costs _____

PAGE 7—Tabulates those items handled as a percentage.



8.

COMPARISON WITH OTHER JOBS

Item	This Estimate Cost	%	Contract Cost	%	Contract Cost	%	Contract Cost	%
Direct Material	$		$				$	
Direct Labor								
Indirect Field Cost								
Office Cost								
Construction Equip. & Tools								
Fee								
Total	$	100%	$	100%	$	100%	$	100%

PAGE 8—Compares estimate to costs of similar projects.

used? Does the customer desire to examine each and every piece of the design, or does he wish only to look at major issues such as the plot plan and the mechanical flow sheets? Does each drawing have to be transmitted to the customer for approval? The extent of this participation in design can affect both the cost and the schedule of the project dramatically.

Page 6. The significant facts involving field labor are listed on Page 6 of the estimate review booklet. Inasmuch as labor productivity varies widely over the United States, it is compared to a base area where the productivity is known. Availability is affected by the volume of work being done in a given area as well as the remoteness of the jobsite. Finally, when is the next round of wage rate increases due?

Page 7. Many items in the estimate are handled as percentages—these items are handled this way because they are either a matter of judgment or are purely arbitrary. These are all tabulated on the seventh page so that all who might have any positive thoughts on what is going to happen at some future date can express themselves. For example, consider a quotation going in today with the possibility of a steel strike around the corner . . . how should material escalation and material deliveries be handled?

Page 8. Finally on the last page, you can compare the major catagories of the estimate to the actual costs of similar projects. If possible, use similar projects constructed in the same area for the same customer. These comparisons are expressed in percentages as well as dollars for each major section of the estimate. These are Direct Material, Direct Labor, Indirect Field Costs, Office Costs, Construction Equipment and Tools, and Fee. Deviations from actual patterns of previous contracts can be very revealing. This sort of comparison is helpful to management in that keeping within fairly narrow limits of previous experience they can develop confidence in the estimate.

In addition to the eight-page booklet, you should provide management with the summary sheet of the estimate which shows in some detail the actual breakdown of the estimate.

Anticipate Questions. The next step in preparation for the estimate review is one of anticipating specific questions which might be asked by management during the review, and to prepare the answers or explanations required. For example, perhaps your estimated engineering costs are higher or lower than the costs of other similar projects. The reasons for this deviation should be ready to state. Such reasons could include: "We are duplicating the reactor section from a previous job," or "The customer has completed the process design," etc.

It is now time for the management review. As estimator you must put on your salesman's hat, for you are now in the process of selling your estimate to management.

One other point worthy of mention, an estimator should use whatever influence he might have to control the size of the review meeting. If possible, see that only those who actually make the decision or those who contribute to the meeting attend. This is very important, for with a large meeting it is difficult to control everyone, and several conversations are running simultaneously and the actual decisions reached may be misinterpreted by some or even all in attendance.

Now, for the review meeting!

The Presentation. First, all present at the review should read their copy of the estimate review booklet. Next should follow a brief verbal description of the project. Such items as escalation, labor conditions, site conditions, weather, and process risks should be highlighted. You should outline any areas of uncertainty or doubt and express your degree of confidence in the estimate. Remember, it will be difficult for management to develop confidence in the estimate if you do not appear to be confident. There is a danger here, though, so you must be frank. If it is a weak estimate, say so—management must have the facts in order to do a good job. Finally, always conclude your remarks with a firm recommendation for action.

At this point management will start firing questions at you. Having anticipated this, however, the answers should be readily available. Remember though, you must avoid being vague . . . if you cannot answer a question, you should state that you do not know the answer. Also, avoid any display of emotion if the estimate is challenged. Be firm in defending your estimate, but not like the proverbial mother hen defending her only chick.

Finally. After these preliminary skirmishes are over, the actual decisions are made. These decisions should be carefully noted, then summarized and played back to the group so that there is no misunderstanding of the actual intent of the decisions. The result of these decisions is then converted into dollars and the estimate adjusted accordingly. At this point, the final estimate total is agreed to and approved.

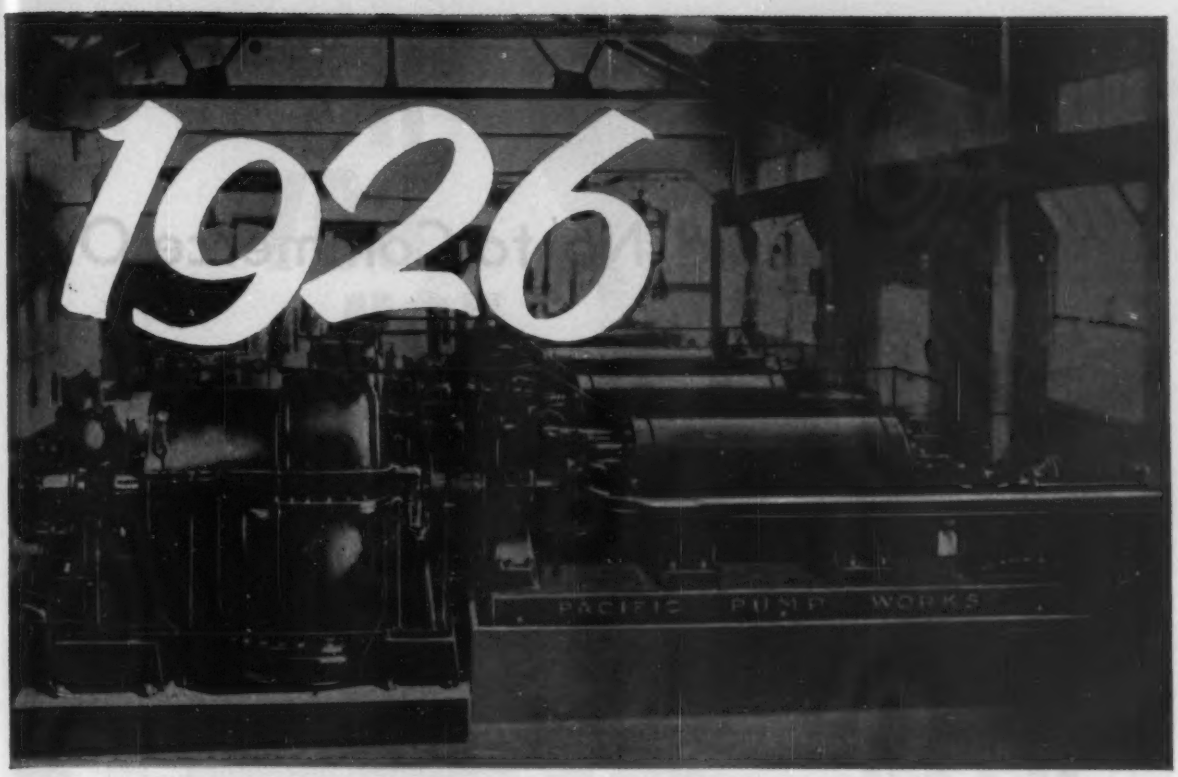
Some may refer to all of this as "Care and Feeding of Management," but the establishment of confidence and understanding of risks involved can only be achieved by giving management all the information and background needed to evaluate any given project.

Estimate reviews should not be a "rubber stamp" operation, but if the right job of presentation and selling is done by the estimator, the estimate will be approved with little or no adjustment.

Originally presented before the American Association of Cost Engineers meeting, Pittsburgh, June, 1959. # #

About the Author

William I. McKay is manager of the Estimating Department, The Fluor Corporation, Ltd., Los Angeles, a position he has held for five years. He was previously a chief estimator for The Refinery Engineering Co., Tulsa, for a year, and was supervising estimator for Bechtel Corp. (San Francisco and New York) for six years. McKay has a degree in physics from San Francisco State College and a graduate degree in meteorology from M.I.T. He is a registered professional engineer in California.



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This first Pacific advertisement appeared in several petroleum publications early in 1927

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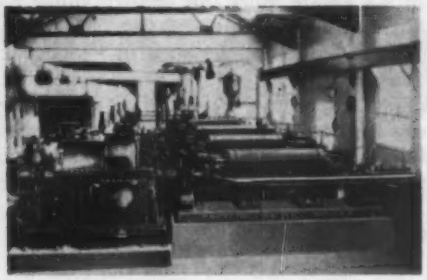

View of recent installation of four "PACIFIC" Multi-stage Pumps at Pan American Petroleum Company Refinery, Los Angeles. Each Pump delivers a capacity of 400 Gallons Per Minute of Oil against a pressure of 2000 pounds. Pumps are driven by 750 H. P. Steam Turbines. Each Pump weighs nine tons and was required to pass a hydrostatic test of 5000 pounds pressure.

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IN-3

Why Courts Said 'No' to Commerce Oil

Here's the full story on the ruling which banned Commerce Oil from building its Rhode Island refinery on the grounds it was a 'nuisance'

Albert Woodruff Gray
Forrest Hills, N. Y.

OPPOSITION TO the construction of a petroleum refinery by the residents of Jamestown, R. I., came recently for determination before the U.S. District Court in that state.

This town is on an island in Narragansett Bay, made up of residents, farms and summer resorts with an area of 9.3 square miles. No industries of any sort are there with the exception of few businesses such as retail shops, stores, hotels and gasoline filling stations.

Across the northern portion of the island is the proposed refinery site of approximately 600 acres. In this tract are but 15 dwellings. About two miles to the south lies Jamestown Shores with about 150 homes and 1.5 miles to the north, more residences, a summer hotel and a camp of 11 or 12 buildings.

Sulfur content. Plans were for the refining of 43,000 barrels of Kuwait crude oil daily, a sour crude with a sulfur content of about 2.5 percent. In commenting on the various refining processes, the court pointed out that there would occur large quantities of hydrogen sulfide which the refiners intend to convert into elemental sulfur, adding that, "Hydrogen sulfide is a particularly malodorous gas described as having the odor of rotten eggs."

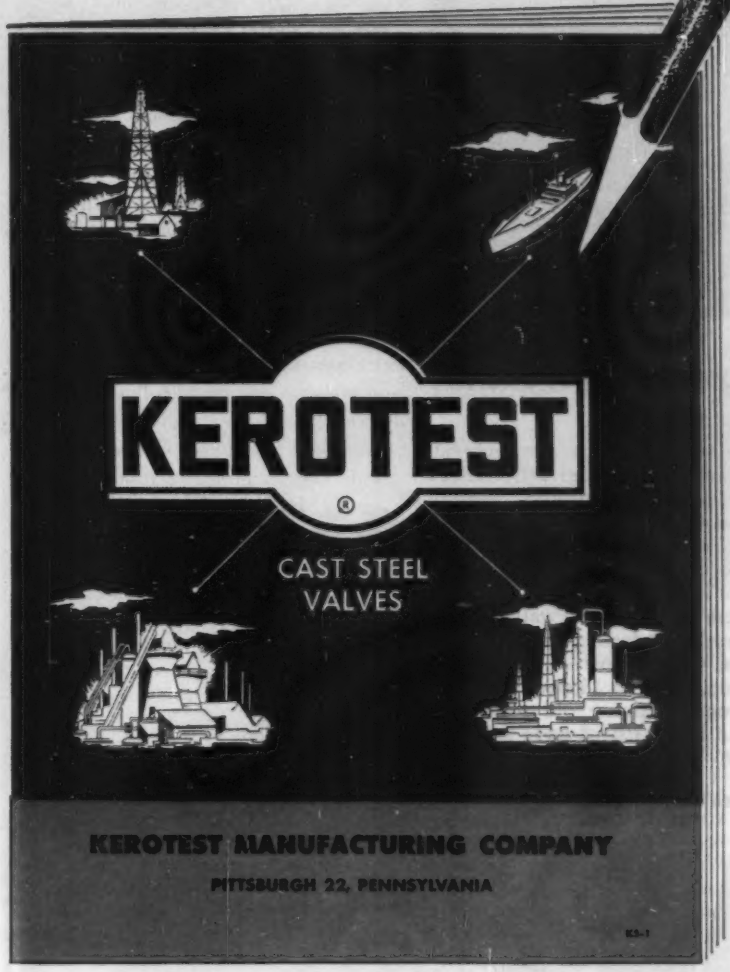
Of the effect of these processes on the residents in the neighborhood, the court continued, "While the proposed refinery is so designed that fuel oil having a sulfur content in excess of 4.5 percent may be burned in its heaters, the company claims that it does not intend to use fuel oils having a sulfur content in excess of 2.5 percent.

"However giving full credence to the company's proposed intention in this regard and assuming that the sulfur recovery unit will operate at all times to its maximum efficiency, it is clear that the minimal quantity of SO_2 to be discharged each day

Residents in the area asked for an injunction against construction of the refinery on the following grounds:

1. The flare on the refinery.
2. The glare from the nocturnal illuminations of the refinery structures.
3. Dust emitted from the catalytic unit.
4. Smoke emitted from the stacks and process heaters.
5. Pollution of the waters used in the refining processes and of waters from the storm water system and by virtue of the spills and leaks in the loading and unloading of tankers.
6. Discharge of SO_2 into the atmosphere.
7. Emission of hydrogen sulfide.
8. Emission of mercaptans.
9. Emission of general refinery odors.
10. Injury to health.

IF YOU USE VALVES



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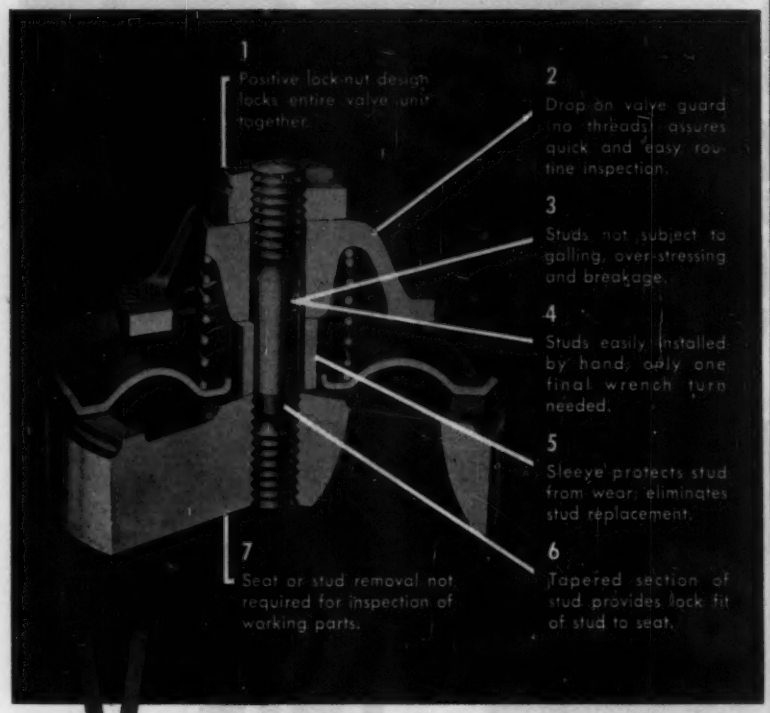
1
Positive lock nut design locks entire valve unit together.
2
Drop on valve guard (no threads) assures quick and easy routine inspection.
3
Studs not subject to galling, over-stressing and breakage.
4
Studs easily installed by hand; only one final wrench turn needed.
5
Sleeve protects stud from wear; eliminates stud replacement.
6
Tapered section of stud provides lock fit of stud to seat.
7
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into the atmosphere will be 37 tons.

"It is detectible in a concentration of 2.5 parts per million of the atmosphere and in concentrations of more than five parts per million, has an irritating effect upon the nose, throat and eyes. If the exposure be for only a few seconds its effect may be only to produce tears. If exposure be prolonged, engorgement of the blood vessels of the eyes and irritation of the nose and throat result."

Use of Water. In addition, it appeared in the progress of this litigation that water from Narragansett Bay would be used for cooling refinery units, amounting daily to at least 100 million gallons which, after circulating through the heat exchangers, would be discharged into the bay. Also an additional 2 million gallons of water a week would be used in refining processes, washing platforms, walks and other areas.

In the recent application to the court by the residents for an injunction against the construction of this refinery, ten features were emphasized as grounds on which this project should be forbidden (see box).

Previous Cases. In its decision in this instance the court followed the determination of a similar controversy which occurred several years before when a group of residents of Everett, Mass., sought an injunction against the Beacon Oil Co., located in an industrial area in that place.

In its refusal to interfere, the Massachusetts court said, "The refining company is engaged in a lawful business in the conduct of which it is found that odors will necessarily escape into the air but it also appears that the company has adopted the most approved methods and devices to control and confine such odors at the expense of many thousands of dollars."

To this comment on the operational methods of the refiner the court added, "Whether there is any nuisance in a certain locality depends upon the attendant circumstances including the character of the neighborhood, the acts complained of and their effect upon the comfort or health of people in general.

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Outside Diameter	Minimum Wall	Length
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3" to 6" inclusive	5/16"	110" maximum
Over 6" to 12" inclusive	3/8"	168" maximum, 24" minimum
Over 12" to 14" inclusive	7/16"	168" maximum, 24" minimum
Over 14" to 20" inclusive	1/2"	180" maximum, 48" minimum
Over 20" to 24" inclusive	1/2"	88" maximum
Over 24" to 32" inclusive	5/8"	80" maximum

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DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

"The district where this plant is situated has for many years been increasingly devoted to manufacturing purposes. Some of the plants were located there many years ago and from some of them odors are thrown off at times which are offensive and disagreeable but as thus discharged by this refinery, are not injurious to the lives or health of normal persons, it cannot be held that a nuisance exists."

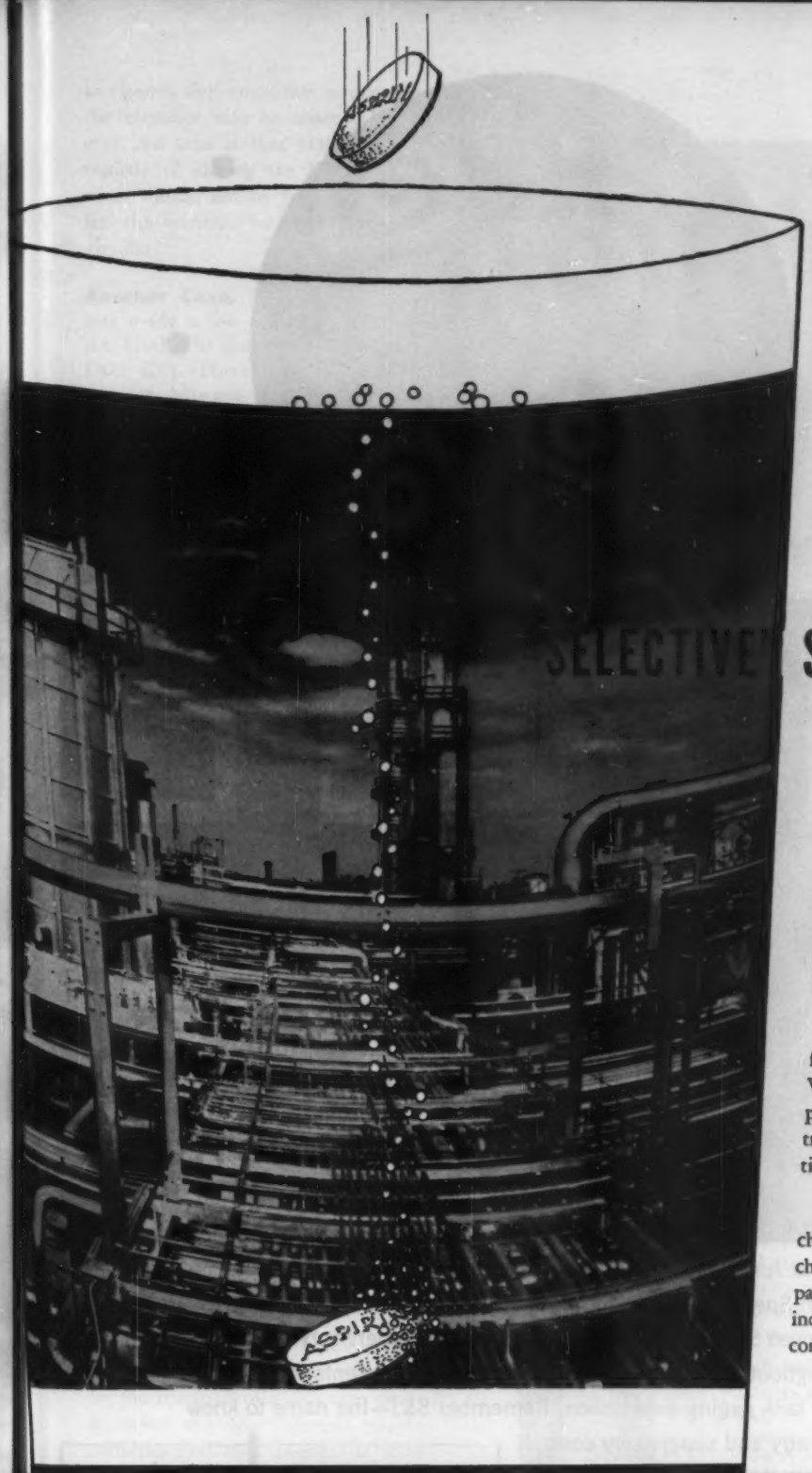
The Difference. Here, however, there is a distinct and clear difference between the circumstances in this instance and those involving the Narragansett Bay refinery. In the earlier case, the plant was not located in a residential but in an industrial area, and the escaping odors were apparently harmless.

Only a few years before this incident in Massachusetts, demands were made by the residents of Covington, Ky., that the court prohibit the operations of the Petroleum Refining Co., in that state. Citizens charged that this refinery had "unlawfully, unnecessarily and unreasonably caused to be emitted noisome, nauseating, dangerous, unhealthy and destructive gases, fumes and odors to the great discomfort, ill health and inconvenience of the residents and citizens residing in said neighborhood."

Here again the courts refused an injunction against these refining operations by saying, "As a general rule every unlawful use by a person of his own property in such a way as to cause material annoyance, discomfort or hurt to other persons or the public generally, and the enjoyment by one of his own property which violates the right of another in an essential degree, constitutes a nuisance.

"The authorities are agreed that a nuisance may consist in the emission of noxious gases or offensive odors in such quantities as to injure the health or materially interfere with the comfort of the public.

"In determining whether or not the refinery is guilty of maintaining a common nuisance, the acts complained of must be viewed in the light of all the surrounding circumstances and conditions and if, when



SERVICE: aromatics to aspirin

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Heat Transfer requirements for petrochemical processes present a worthwhile challenge, and Western will continue to expand its sphere of influence in the petroleum industry's growing importance to chemical consumers.

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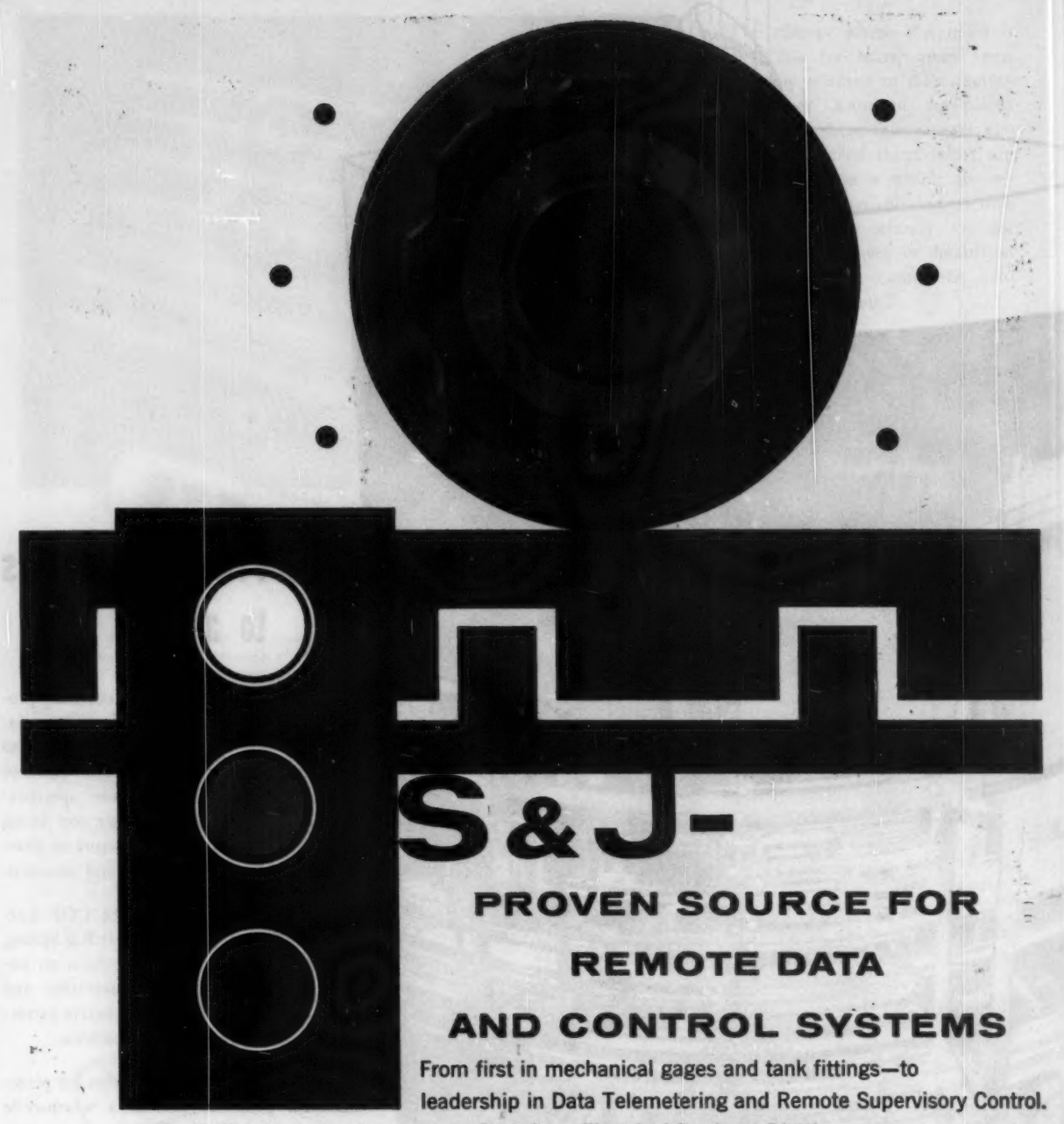

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That's the Shand and Jurs story. Out of our Electrical Products Division comes S&J High Speed Telepulse for telemetering level, temperature, pressure and function control. Proven S&J Gardtrol is serving in remote supervisory control applications throughout the country. And S&J Datalogger presents the latest achievements in tank gaging automation. Remember S&J—the name to know in telemetry and supervisory control.

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so viewed, they constitute a nuisance the nuisance may be abated. However, we take it that extraordinary remedy of closing the business entirely should not be resorted to unless the evidence be clear and convincing."

Another Case. This same charge was made a few years later against the Utah Oil Refining Co., in Salt Lake City. There too, a distinction appears between the situation on that island in Narragansett Bay with its nine-mile area of families and summer homes and that of this Utah refinery in a neighborhood of railroad roundhouses of the Oregon Short Line Railroad, a gravel pit and rock crusher.

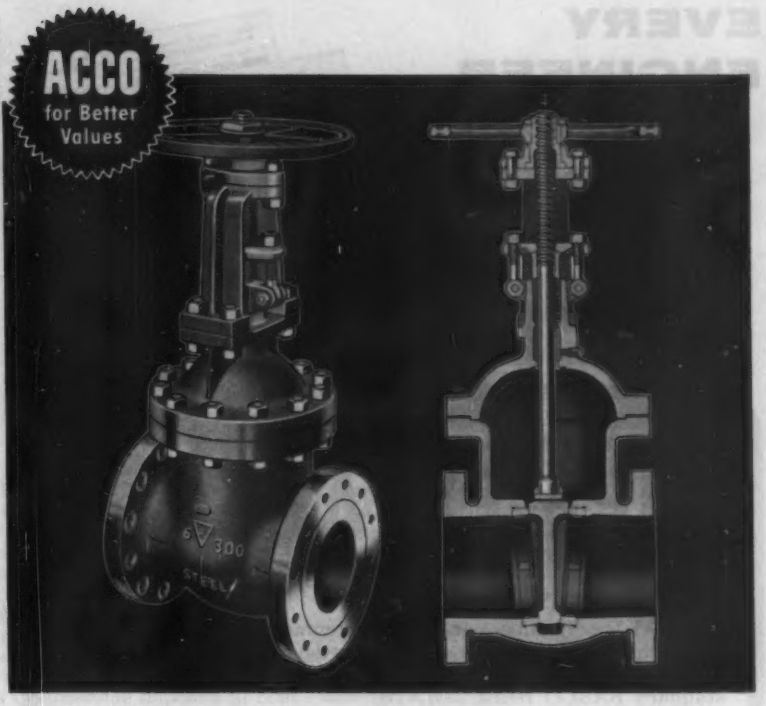
"Every person has the right to the reasonable enjoyment of his property," said the Utah court here. "As to what is a reasonable use of one's property must necessarily depend upon the circumstances of each case, for a use for a particular purpose and in a particular way in one locality that would be lawful and reasonable, might be unlawful and a nuisance in another.

"A business which might be perfectly proper in a business or manufacturing neighborhood, may be a nuisance when carried on in a residential district and, conversely, a business which with its incidents might be considered a nuisance in a residential district may be proof against complaint where conducted in a business or manufacturing locality."

Here are two contrasting features, each of equal importance, the rights of industry in the conduct of business and the rights of residents in the enjoyment of their homes.

An Old Problem. Even many years ago in England an action was brought by the residents of a 485 acre estate to enjoin the operation of nearby collieries and coke ovens. "If some picturesque haven opens its arms to invite the commerce of the world," said the English court in denying the application for an injunction, "it is not for this court to forbid the embrace . . ."

Nearly a century ago in one of



Choose R-P&C cast steel valves in 7 pressure classes (150 lb. through 2500 lb.) for dependable strength and quality

• R-P&C Cast Steel Valves—with primary ratings of 150 lbs., 300 lbs., and up to 2500 lbs.—are ideally suited to the high-pressure, high-temperature demands of the petroleum industry and of steam power plants. Here are some of the reasons:

STRENGTH • The design of R-P&C Cast Steel Valves embraces ample metal walls which exceed Code specifications. All components are designed and built to assure that valves conform to A.S.A. and A.P.I. requirements.

QUALITY • Castings for Steel Valves are made in R-P&C's own foundry. They are produced under direct supervision and control of R-P&C technical personnel. These castings are subject to critical inspection. R-P&C's inspection facilities embody latest methods of non-destructive testing—including a 2-million volt X-Ray machine for the internal examination of High Pressure valve castings.

DEPENDABILITY • R-P&C Valves are carefully assembled to assure proper fit of all parts and good mechanical operation. They are individually tested to fully conform to specifications or Codes as required. No valves are released from production until they have completely and satisfactorily met inspection and test requirements.

SEND FOR FREE WALL CHART

"How to Protect Your Valves"
This 22" x 17" chart gives valuable installation pointers, operating tips, clues to longer service life. For free copy, write us at Reading, Pa.

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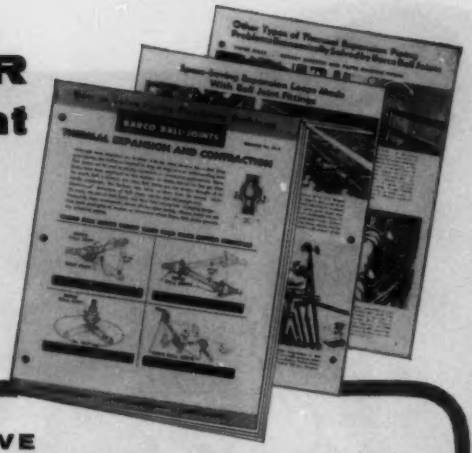
EVERY ENGINEER will want these FACTS!

NEW EDITION
Bulletin No. 31-A



"HOW TO SOLVE

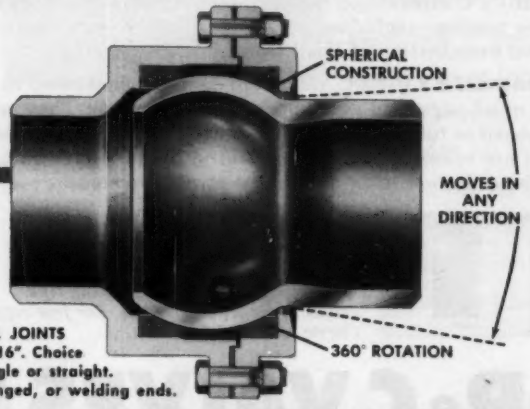
PIPE EXPANSION

PROBLEMS"

TODAY there is an easier way to accommodate *thermal expansion* in piping! No need to install special devices—in virtually every instance, you can put *flexibility* right in the line itself with standard BARCO BALL JOINTS:

1. **SUPERIOR METHOD.** New Steam Power Stations . . . Oil Refineries . . . Chemical Plants . . . Paper Mills . . . Office Buildings . . . Schools now are using this money-saving method.
2. **LONG LIFE.** No rubber, no thin metal members subject to fatigue or "blow-out." No lubrication, no grease packing. Self-adjusting; pressure sealing.
3. **FIRE-SAFE.** The joints have passed rigid fire, high temperature, and water quench tests.
4. **SAVE SPACE, CUT COSTS.** No pressure thrust—expensive anchoring or bracing not required to hold piping in place or in line. Cuts space required for pipe loops and U-bends.
5. **VERSATILE.** Easy to handle compound twisting movements, wide variations in temperature and pressure—steam, air, oil, water, gas and chemicals.

SEE your Barco Representative for information or write. Ask for the new revised Bulletin No. 31-A, "How to Solve Piping Flexibility Problems." *Engineering recommendations on request.*



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Sizes ½" to 16". Choice of styles, angle or straight. Screwed, flanged, or welding ends.

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the cities in New Jersey a potter undertook the construction of a three story building containing two furnaces and two kilns for firing earthenware in which pine wood was to be used as fuel. Action for an injunction against the construction of this building was brought by nearby residents on the ground that this portion of that city was thickly populated and that the operation of this pottery would greatly depreciate the value of the property and that its conduct in the manner planned would be a nuisance.

Injunction against this use of the building was granted. "The law takes care that lawful and useful business shall not be put a stop to on account of every trifling or imaginary annoyance such as may offend the taste or disturb the nerves of a fastidious or very refined person," said the court in reference to the right of these property owners.

"But on the other hand, it does not allow anyone, whatever his circumstances or condition may be, to be driven from his home or to be compelled to live in positive discomfort although caused by a lawful and useful business carried on in his vicinity.

"In accordance with this view it is settled in England and in this country that smoke or offensive vapors, or noise, although not injurious to health, may constitute nuisance, the only question being whether the degree or extent is such as to interfere materially with the comforts of life."

What Is A Nuisance? In conclusion the court added a summary of that debatable middle ground lying between the circumstances under which the injunction was granted against the construction of the Narragansett Bay refinery and the refusal of that English court to forbid the conduct of the collieries near that 500-acre country estate.

"But the question remains," continued the court, "what degree or amount of discomfort is necessary to constitute a nuisance. It is clear that everything that renders the air a little less pure or is to any extent disagreeable, is not necessarily a nuisance.

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proves superior as detergent, corrosion inhibitor or anti-icer!

Added to your gasoline as anti-icer, UNICOR LHS does an effective job in preventing carburetor icing and consequent stalling. In addition, UNICOR LHS imparts greater detergency to your gasoline than the best competing additives —and at lowest cost.

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A surface active additive, soluble in all hydrocarbons including liquid propane, UNICOR LHS safeguards pipelines and refinery equipment against corrosion. It is also a highly effective detergent—eliminates troublesome deposits in heat exchangers, promotes cleanliness of refinery equipment.

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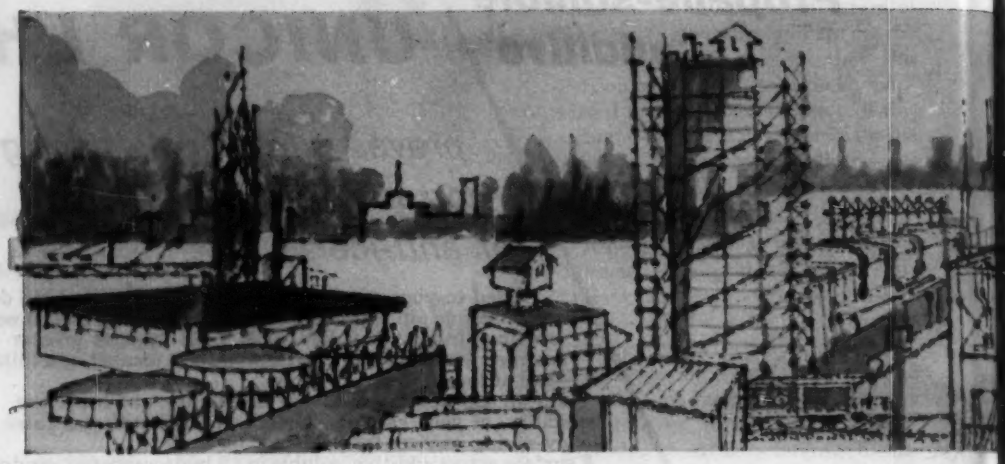
ENGINEERING AT ITS BEST



WHAT YOU SHOULD EXPECT

When you go to an engineering firm for help in the design and construction of a new plant, or the expansion of existing facilities, you have a right to expect certain basic standards from that firm. They should have EXPERIENCE, for only with past experience can you minimize the number of new problems which will arise on any new project. Such experience, however, should be tempered with FLEXIBILITY, CREATIVITY and VISION. Some companies are experienced beyond measure at building plants from designs more than 25 years old. In the highly competitive years ahead, such plants could prove economically unsound. You owe it to your company's future to select a firm which has proven its ability to provide the newest and the best in process engineering.

For almost half a century, CHEMICO has maintained a reputation for progressive and imaginative process design and improvement. This proven "know-how" is available to firms in the chemical and petrochemical fields requiring any and all types of engineering and construction services.

WAYS OF WORKING WITH THE CLIENT

A recently completed petrochemical plant offers the best example of the several ways in which CHEMICO is prepared to work with its clients. This huge complex was designed to produce acetylene derivatives, and included processes for producing a wide range of basic chemicals. The ammonia, sulfuric acid and ammonium sulfate sections of this plant were based on *Chemico's own proprietary processes.* The designs for the acrylonitrile and hydrogen cyanide units were based on processes developed in the *client's own pilot plant.* For the acetylene plant, CHEMICO *obtained a license* from BASF in Germany for their patented production-proven process. The oxygen plant was designed by the Linde Company of Germany on a *sub-contract basis.* CHEMICO's Construction Department was responsible for erection of all the plants, and CHEMICO's Industrial Projects Department supervised, coordinated and controlled the entire project.

CHEMICO is always prepared to provide its services to clients on any or all of the bases indicated above. For clients with processes of their own, CHEMICO's Industrial Projects Department will engineer and construct plants, starting at any stage of development. CHEMICO's own laboratories and pilot plant are available, if desired, for process development and improvement work on a contract research basis. If the process to be employed has already undergone pilot stage testing, CHEMICO will design the most economic and efficient commercial scale operation. In such a case, the client can be sure that CHEMICO will call on the services of outstanding engineers and technical personnel with experience similar, or related to the unit operations which are to be designed, engineered and constructed. In addition, the client can be assured that CHEMICO, as an independent engineering organization, will undertake such activities in the framework of a completely confidential relationship,

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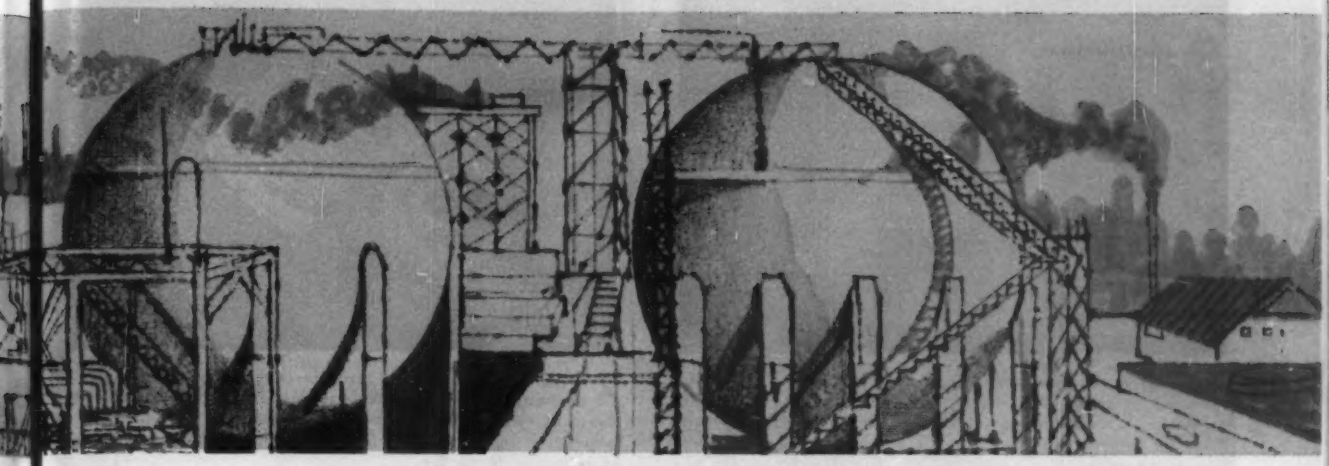

with all necessary safeguards for protecting the client's competitive position in regard to trade secrets and research developments.

In the case of clients who want plants to produce products for which neither CHEMICO nor the client has a process, CHEMICO, through its Industrial Projects Department, will obtain licenses from whatever source possible for production-proven process designs which will enable the engineering and construction of the desired plant.

Very often CHEMICO's drafting force as well as its specialists in civil engineering, mechanical engineering, electrical engineering and other service engineering capacities can be made available to clients on an individual contract basis. CHEMICO's construction organization, made up of a permanent force of highly experienced construction superintendents, is prepared to undertake a wide range of erection projects related to the process industries.

CONTRACT ARRANGEMENTS

CHEMICO offers its clients a wide choice in the type of contract under which each individual project is to be handled. Among the more common arrangements—although by no means the only ones available—are the following:

Cost Plus Fixed Fee: Under this type of contract, CHEMICO's fee and overhead charge for engineering, construction and related services is decided by mutual agreement, and the client is billed at direct cost for any and all expenses incurred by CHEMICO to complete the client's project.

Lump Sum: At the client's request, CHEMICO submits a firm estimate containing a specific price for which CHEMICO will undertake to complete the client's project.

Guaranteed Maximum: Under this type of contract, CHEMICO will set a maximum cost to the client for an individual project. If the cost of the project falls below the maximum figure, all savings will be divided between CHEMICO and the client on the basis of a prearranged rate.

Fixed Price Equipment Supply: Under this type of contract, the client gets the benefit of CHEMICO's design, engineering, purchasing and expediting services, but is free to make his own arrangements for the construction of his project.

Basic Design and Construction Supervision: This type of arrangement has proved extremely useful in dealing with clients outside the United States. Ordinarily, under a contract of this sort, CHEMICO provides the basic engineering for a project, and the client makes other arrangements for the detailed drawings and construction. CHEMICO then supervises construction and sees the project through start-up operations.

CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
525 West 43rd Street, New York 36, New York

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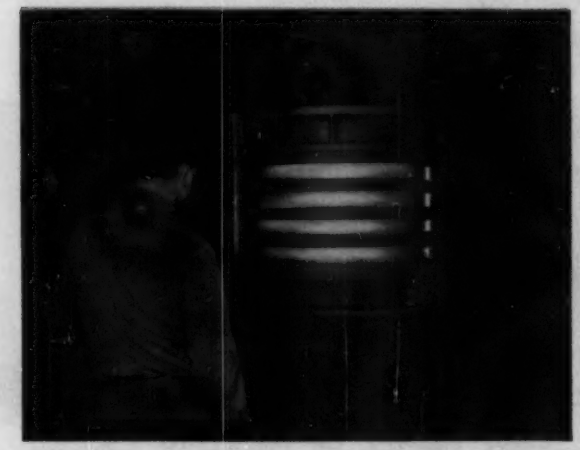
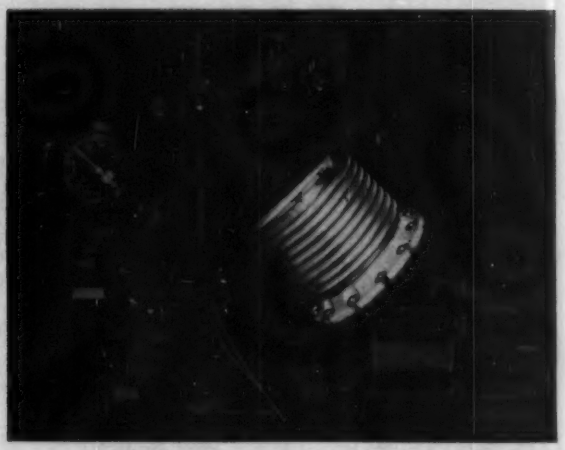
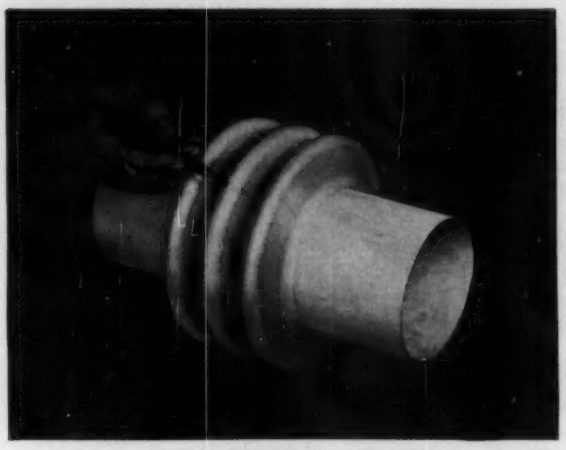
4 WAYS to get maximum reliability in expansion joints



1 Insist that the corrugated bellows be hydraulically formed. The reason is simple. Whenever bellows are formed by circumferential welding . . . whether by edge, seam or fillet welding . . . they will always be subject to premature failure because of stress concentrations at the welds.



2 Be sure the manufacturer maintains a continuous and comprehensive program of endurance testing. This is basic, because of the many variables that affect expansion joint life. Accurate determination of expansion joint life expectancy can only be determined by cycling to destruction.



3 Demand proof that the manufacturer can produce longitudinal welds in the corrugated bellows having the same strength, physical properties and thickness as the parent metal . . . without grinding. A weld that is hard to find is a ground weld. Variations in weld thickness set up points of stress concentration . . . opening the way for premature failure.

4 Check the ability of the manufacturer to supply a team of *competent* design and application specialists to work with your engineers. Check their specific experience in handling critical, complex applications in your field . . . complete to the record of successes or failures behind them, and details of how this experience will be brought to bear on your problem.

At Zallea, none of the many factors affecting expansion joint reliability are left to guesswork . . . including the four vital ones above.

This is reflected in these facts. Zallea material specifications are the most exacting in the industry. Zallea expansion joints are hydraulically formed. Zallea advanced welding techniques insure welds having the same thickness, strength and physical properties as the parent metal. Zallea has done more cyclic testing to destruction than all government agencies and industrial firms combined. Zallea has produced more expansion joints than any other manufacturer . . . offers more application engineering experience.

For all the facts, write for Catalog 56. Zallea Brothers, Taylor and Locust Streets, Wilmington 99, Delaware.

Zallea for maximum reliability

ZALLEA BROTHERS, Wilmington 99, Delaware • World's largest manufacturer of expansion joints

"The smoke that may in certain conditions of the atmosphere descend from a neighbor's chimney, the fumes that may be sometimes wafted from his kitchen, though not desirable or agreeable, are not a nuisance.

"Between them and the dense smoke from a kiln or factory, that renders breathing difficult and painful, and offensive to the verge of nauseating, there is a debatable ground on which it may be difficult to fix the exact point at which the smoke or smell becomes a nuisance in the eye of the law."

To Each His Own. Another decision which the federal court in Rhode Island followed as an authority was one before the New York State Court of Appeals. "It is a general rule," said the court in this decision that has become a leading authority in relation to this feature of the law, "that every person may exercise exclusive domain over his own property and subject it to such uses as will best subserve his private interests. Generally no other person can say how he shall use or what he shall do with his property.

"But every person is bound to make a reasonable use of his property so as to occasion no unnecessary damage or annoyance to his neighbor. If he makes an unreasonable and unwarrantable or unlawful use of it so as to produce material annoyance, inconvenience, discomfort or hurt to his neighbor, he will be guilty of a nuisance to his neighbor and the law will hold him responsible for the consequent damage.

"As to what is a reasonable use of one's property cannot be defined by any certain, general rules, but must depend upon the circumstances of each case. A use of property in one locality and under some circumstances, may be lawful and reasonable, which under other circumstances would be unlawful, unreasonable and a nuisance.

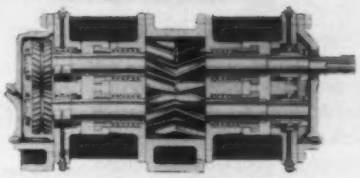
"To constitute a nuisance the use must be such as to produce a tangible and appreciable injury to neighboring property as such, as to render its enjoyment specially uncomfortable and inconvenient."

Sier-Bath GEAREX® PUMPS

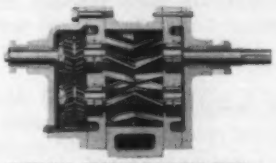
provide high-volume, low-maintenance pumping at Tank Farm of SUN OIL COMPANY, Ltd. (Sarnia Refinery)

● In 1956, three Gearex Rotary Pumps were installed to pump No. 6 Fuel Oil from storage tanks to the bulk sales area for tank truck distribution. Each pump has a capacity of 400 gpm. at 70 psi., handling oil with a viscosity of 100-150 SSU at 200°F. One pump operates continuously, one intermittently, one is for emergency reserve. Originally selected as the most economical pumps for the job, the Gearex Pumps are giving excellent service and have required very little maintenance.

***Sier-Bath* "Gearex" Pumps**



EXTERNAL GEAR & BEARING TYPE
for non-lubricating liquids



INTERNAL GEAR & BEARING TYPE
for lubricating liquids

Sier-Bath "Gearex" Pumps provide positive displacement, pulseless flow . . . quiet, vibrationless operation. Direct-connected up to 1800 RPM, they require no reduction gears. For high volumetric efficiency and long life there is no rotor-to-rotor or rotor-to-casing contact. Low pressure on stuffing boxes provides easy servicing.

Horizontal or vertical models to handle 32 to 500,000 SSU, 1 to 550 GPM at 250 PSI for viscous liquids, 50 PSI for water. Corrosion-resistant alloys, steam-jacketed bodies, water-cooled bearings, other adaptations to meet individual needs. See "Yellow Pages" for your local Sier-Bath Pump Representative or send for Bulletin G-2. *Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Blvd., North Bergen, N. J.*

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Founded 1905 · Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings · Member A.G.M.A.

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IONIZATION DETECTOR

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Analyzes a wider range of samples, including fixed gases

Non-radioactive, no hazardous materials are used

At least 1000 times more sensitive than thermal conductivity

Analyzes small samples with capillary or packed columns

Answering the need for better detection methods in chromatographic analysis, Burrell has developed a new ionization detector for use with the Burrell Kromo-Tog. Electrons for ionization are supplied by emission, providing extremely high sensitivity and fast linear response. Changes in flow or temperature have no adverse effects. Ready control of the ionizing energy provides flexibility for many special techniques. Method is non-radioactive.

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BURRELL IONIZATION DETECTOR, Complete with detector cell and electronic controls but without vacuum pump.

For The Kromo-Tog, Models K-1 or K-2, right-hand side
Cat. No. 340-250.....**1500.00**

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Final Ruling for Commerce. Against this background of the law set out in these decisions over the past hundred years the court in Rhode Island said in conclusion,

"Insofar as SO_2 is concerned, it is abundantly clear that at least 37 tons thereof will be discharged into the atmosphere each day. It is anticipated that this malodorous gas is detectable by smell in a concentration of 2.5 parts per million and that in concentrations of more than five parts per million it has an irritating effect of varying degrees, depending upon the health of the individual and the length of his exposure to it.

"The creditable testimony satisfies me that depending upon atmospheric conditions, wind velocities and the prevailing winds, there will be frequent concentrations of SO_2 in excess of 2.5 parts per million and that it is reasonable to conclude that the properties of these residents will be frequently visited with similar concentrations carried to their premises by the prevailing winds and that these concentrations will serve to effect a substantial diminution in the values of their properties and in the enjoyment thereof.

"I am satisfied after a careful consideration that the operation of the said refinery in the manner and at the location proposed, will cause a substantial diminution both in the values of the properties and in the enjoyment thereof as measured by the degree of comfort which the average man, living in such a locality has the right to expect. It follows that said use will be unreasonable and hence, a nuisance to these residents against which they are entitled to injunctive relief."

Thus, up went the legal barrier which kept Commerce Oil from constructing its refinery at Narragansett Bay, R. I.

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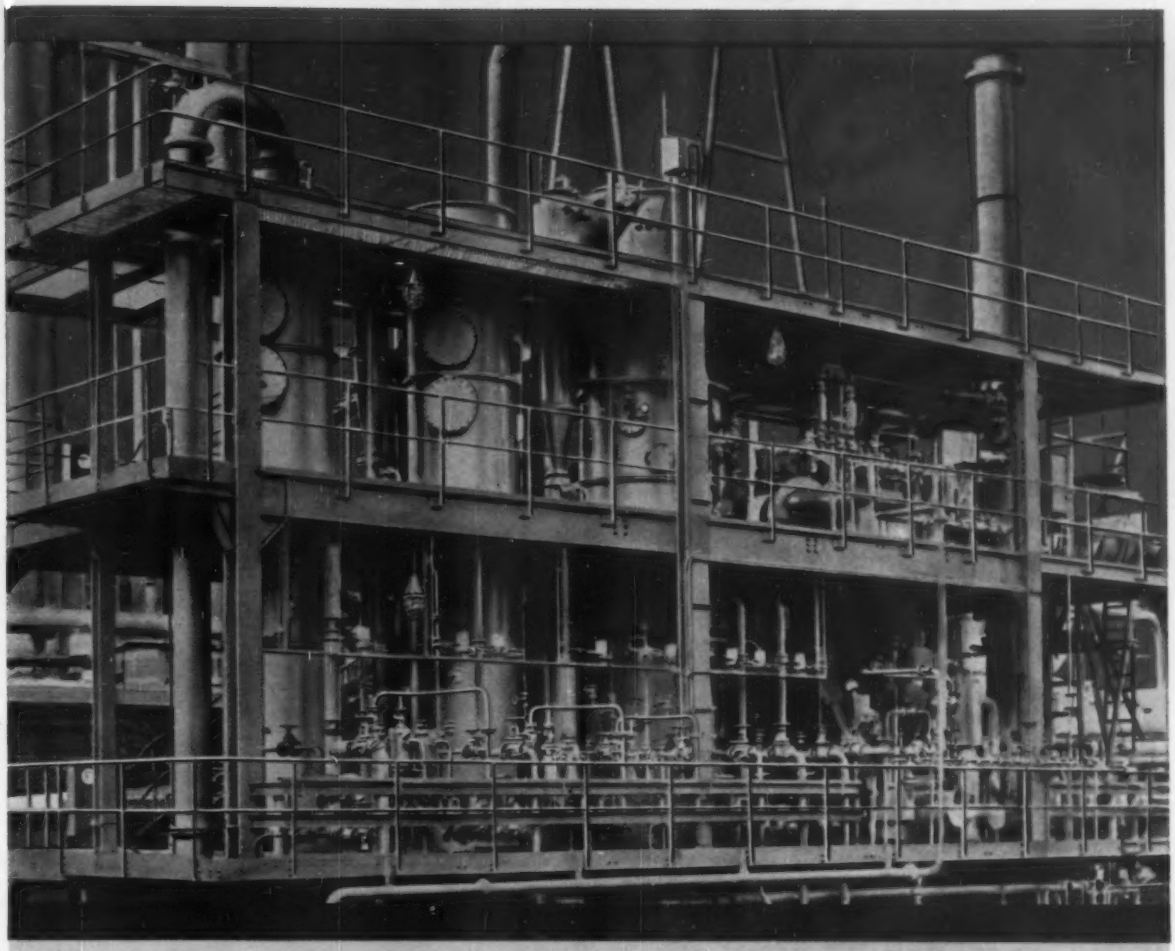


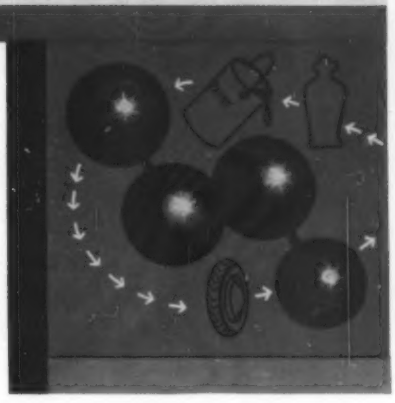
Exclusive with Stone & Webster Engineering Corporation:

New Eastman Flame Cracking Process

The world's first commercial plant capable of simultaneous production of acetylene and ethylene from hydrocarbon feed stocks today operates successfully at Chemische Werke Hüls in Germany.

Through an exclusive arrangement, Stone & Webster Engineering Corporation now makes this new Eastman Flame Cracking Process available to industry. The commercially proven method, developed by Tennessee Eastman Company, a division of Eastman Kodak Company, produces yields from raw materials in excess of 50 weight percent.

Stone & Webster's broad experience in process engineering throughout the world will be fully utilized in the design and construction of new plants using the Eastman process. For full details, call or write our nearest office.



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August 27, 1959—Oil's 100th Birthday

A Great Day for Every Oil Man and Woman

100 years ago Colonel Edwin L. Drake drilled the first commercially successful oil well.

Of all the many uses for petroleum during the past century—as an illuminant, a lubricant, a source of chemicals—its most important use has been *as a source of abundant, low-cost energy*.

The progress of any nation can be measured by the amount of energy it consumes—for heat, light, transportation, agriculture, industry.

We in America produce and use 40% of all the energy consumed in the world—enjoy the highest standard of living in the world. More than two-thirds of our energy comes from oil and natural gas.

By August 27, 1975, America's energy needs will have doubled. Oil and natural gas will be called upon to supply two-thirds of this need—or 30% more energy than we now derive from all energy sources combined.

Every oil man and woman shares a quiet pride in the progress of our first century—and confidence in our ability to meet the challenges of the second.

As we look ahead to our second century, we join all other American business and industry in giving thanks for America's unique climate of freedom—from which all *past* success has come . . . on which all *future* success depends.

Committee on Public Affairs
of the
American Petroleum Institute
50 West 50th Street • New York 20, New York

TABLE 1—Octane Ratings of U.S. Gasolines

Survey Period	OCTANE NUMBER					
	Regular-Price		Premium-Price		New Grade	
	Research	Motor	Research	Motor	Research	Motor
Summer 1956	88.8	82.6	96.4	86.2	.....	....
Winter 1956-57	89.1	83.1	96.7	86.8	100.7	90.1
Summer 1957	89.8	83.2	97.6	87.4	100.9	90.5
Winter 1957-58	90.0	83.4	98.0	87.8	101.1	91.1
Summer 1958	90.2	83.4	98.4	88.4	101.4	92.2
Winter 1958-59	90.6	83.6	98.9	88.9	101.8	92.6

Octane Ratings Continue Upward Climb

Bureau of Mines reports the octane ratings for U.S. gasolines marketed in various districts

Further advances of octane numbers of motor gasolines are revealed by the recent report of the Bureau of Mines, Petroleum Products Survey No. 10, "Motor Gasolines, Winter 1958-59." Part of this trend may be ascribed to premium-price fuels having octane values of 100 and over, manufactured by companies who market only two grades of gasoline in contrast to refiners who sell three grades—regular, premium, and the new grade.

The new-grade fuel was the first 100-octane motor gasoline sold for general use and is on the market for the third year. National averages of octane numbers of the three types of fuel from surveys of recent years are shown in Table 1.

A grand total of 5,777 samples, from service stations through the country, was collected for the Winter, 1958-59 survey by oil, motor, and chemical companies and analyzed in their laboratories under a cooperative agreement between the Bureau of Mines and API. The samples, representing products of 100 companies, large and small, which manufacture and supply motor gasoline, revealed that regular grades had an average octane rating of 90.6; the premium grades, 98.9; and the super grades, 101.8. These represented gains of 0.4 of a point for the regular and super grades over the Summer of 1958 and an increase of 0.5 of a point for the premium grades.

For those who seek comparisons, the Bureau pointed out that 10 years ago the average regular-grade gasolines had an octane rating of 80.5

TABLE 2—Octane Ratings of U.S. Gasoline by Districts

District	OCTANE NUMBER					
	Regular-Price		Premium-Price		New Grade	
	Research	Motor	Research	Motor	Research	Motor
1. Northeast area	93.4	84.9	99.1	88.6	101.7	93.9
2. Mid-Atlantic Coast region	92.9	84.8	98.9	88.7	101.7	92.7
3. Southeast area	91.3	84.0	98.6	88.3	101.5	92.2
4. Appalachian area	92.8	85.1	99.0	89.4	102.0	92.0
5. Michigan	92.8	84.3	99.1	89.5	102.1	92.1
6. North Illinois area	92.3	84.9	98.9	89.5	101.6	91.2
7. Central Mississippi area	91.7	84.5	98.8	88.8	101.7	92.1
8. Lower Mississippi area	90.3	84.2	98.6	89.1	102.0	93.2
9. North Plains area	89.7	83.4	99.1	89.3	.....	.....
10. Central Plains area	89.3	83.9	98.4	89.5	.....	.....
11. South Plains area	89.7	83.7	99.0	89.2	102.1	92.0
12. Southern Texas	90.3	84.3	98.7	89.2	101.8	93.6
13. South Mountain States	87.9	81.5	97.6	88.8	101.6	93.7
14. North Mountain States	89.8	81.4	98.5	87.5	.....	.....
15. Pacific Northwest	88.9	82.3	99.5	88.8	.....	.....
16. Northern California	89.1	82.5	99.6	88.3	.....	.....
17. Southern California	88.4	81.3	99.4	88.5	.....	.....
National average	90.6	83.6	98.9	88.9	101.8	92.6

and premium-grade fuels, 86.5. Thus, in a decade, octane ratings for regular-grade gasolines have risen 10.1 points and those for premium fuels, 12.4 points. No super-grade gasolines were available to motorists 10 years ago.

Among the thousands of samples analyzed during last Winter's survey, the following represents highs and lows in the three grades of gasoline:

Regular, 83 low, 94.6 high; premium, 92.5 and 100.8; Super, 100.4 and 102.5. Although none of the super grades fell below 100.4, premium gasolines with ratings of over 100 octane were encountered with increasing frequency. The Bureau reported that one-premium-grade gasoline reached an octane of 100.8, which was better than the lowest super-grade gasoline analyzed.

In addition to octane numbers, tests were made for gravity, corrosion, percent sulfur, contents of gum and tetraethyllead, Reid vapor pressure, and distillation temperatures.

The data are tabulated by groups according to 17 marketing areas (districts) into which the country is divided. The report also contains charts indicating the trends of selected properties of motor fuels over a number of years, and a map showing the current sampling locations and the districts.

Table 2 shows the average Research and Motor-method octane numbers of the three grades of gasoline sold by districts during the winter of 1958-59.

Sales of Crude Products for Chemical Conversion Up

U.S. output and sales of "crude products from petroleum and natural gas for chemical conversion" increased about 15 percent each in 1958, says the U.S. Tariff Commission. Output amounted to 29,903-million pounds compared with 18,094-million pounds in 1957. Sales in 1958 amounted to 11,904-million pounds valued at $380 million, compared with sales of 10,330-million pounds, valued at $376 million, in 1957.

The report, covering output and sales of synthetic organic chemicals in 1958, gives preliminary figures (about 95 percent complete) on aromatics, naphthenes and aliphatic hydrocarbons. Separate data is included for benzine, toluene, xylene, cresylic acid, napthenic acids, ethane, ethylene, propane and butadiene.

Output of all aromatic and naphthenic products in 1958 amounted to 5,285 million pounds, about 48 percent more than in 1957. Sales of aromatic and naphthenes in 1958 totaled 3,412 million pounds, valued at $98 million, compared with 2,429 million pounds, valued at $87 million, in 1957.

Pemex Asks Mexico for Petrochemical Monopoly

Petroleos Mexicanos has asked the Mexican government to include an extensive list of petrochemical products among items in which Pemex will have monopoly of production and sales. The list is in two parts: Items for which Pemex will build plants under financing already available to it, and items for which no firm manufacturing plans have been made by Pemex.

Any item in either part of the list may continue to be imported in normal trade until Pemex is ready to begin sales of each item. A list of items for which plant financing has been achieved is as follows: butadiene, toluol, anhydros ammonia, methanol, benzol, ethylene, xylol, acetone and polyethylene.

A list of items for which plant financing has been completed is as follows: acetylene, methylene chloride, isopropylic acid, acetic acid, carbon bisulfide, cumene products (isopropyl benzine and isopropyl benzol), chloroform, propylene, acetic anhydride, amylic alcohol, carbon tetrachloride, nitroparaffin, and a sizeable list of polymers.

Symposium Will Cover The Next 100 Years

"The Next One Hundred Years" is the title of a coming petroleum symposium at the University of Houston in which leaders from industry, science, and education will exchange views on the prob-

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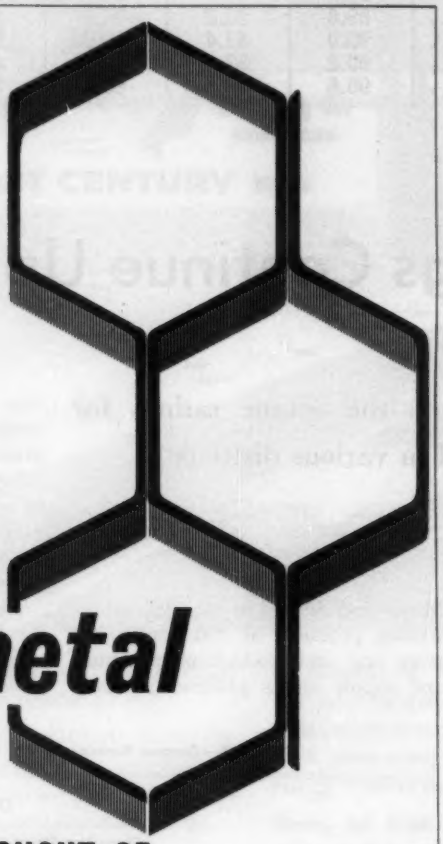

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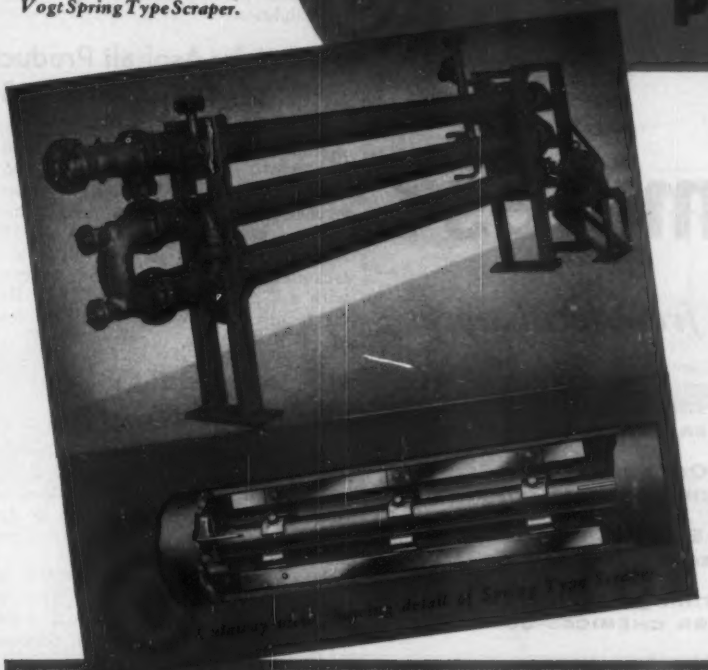

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lems of the next one hundred years. Purpose of the symposium is to provide an atmosphere for the exchange of ideas among educators, scientists, and leaders in the petroleum industry and government. To be held on the campus of the University of Houston, August 26-27, the symposium is being sponsored jointly by the petroleum industry and the university. Main topics will be Energy Sources for The Next 100 Years, The Challenge to Management, Moral Commitment to the Coming Generation, Population and its Problems and The Emerging Nations.

Gulf Oil's Political Program Firmed Up, Says Official

Gulf Oil Corp.'s now-firmed-up political program has been described as nonpartisan and long-range in scope, "encompassing everything from the local to national level that politically affects the company's ability to do business."

A. F. Lorton, Jr., Houston public relations representative for Gulf, told a personnel association meeting company's program calls for:

- Appointment of specially trained employes as regional or area political supervisors who will work directly with politicians for mutual understanding.
- A new Washington office to include a legislative analyst and political writer who will be a registered lobbyist and public relations representative. The office will supply regional supervisors with voting records and other information on "all congressmen from the states in which Gulf has an interest."
- Preparation of a bi-weekly newsletter in Washington summarizing all legislative activity pertaining to oil industry.

"Gulf employes will be encouraged to become effective voices in any political party in which they choose to be active," Lorton said. He added that the company will consider granting leaves of absence to employes who may be elected to public office and will encourage employes to undertake part-time civic or political responsibilities.

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Market for Asphalt Products Increases 11 Percent in '58

The market for asphalt and asphaltic products increased 11 percent in 1958 to 18,179,099 short tons, according to a survey made by the Interior Department. Asphalt sales have shown steady annual increase with the exception of 1957. Asphalt sales for paving purposes increased 12 percent in 1958 compared with a 2 percent decrease in 1957. Road oil requirements were 11 percent lower in 1958.

U.S. Imports of Crude Slack Off in April

U.S. imports of crude and products into continental U.S. dropped in April to 1.43 million bpd from 2.9 million bpd in March and from 1.6 million in April 1958, according to Bureau of Census statistics.

Crude imports averaged 789,000 bpd compared with 988,000 in March and 872,000 in April, 1958. Residual imports averaged 489,000 bpd in April, compared with 959,000 in March, and 557,000 in April, 1958. April crude and products imports into Alaska, Hawaii and Puerto Rico averaged 61,033 bpd, compared with 75,794 in March and 54,021 in April a year ago.

Domestic Demand for Oil as Energy Fuel Soon to Double

Domestic demand for oil as an energy fuel in the next five years will double its annual growth rate of past years, increasing at roughly 3 percent per year, predicts Socony Oil Co.'s general counsel John J. Scott, at a panel on competitive fuels sponsored by National Coal Association. Scott and Raymond E. Salvati, president, Island Creek Coal Co., both painted bright forecasts of future markets for all fuels, but clashed over coal industry campaigns for tighter import curbs on residual fuel oil. Both expressed concern over the growth of natural gas markts.

By 1963, said Scott, U.S. consumption of energy will be up 20 percent over last year to 1.9 billion tons in coal equivalent.

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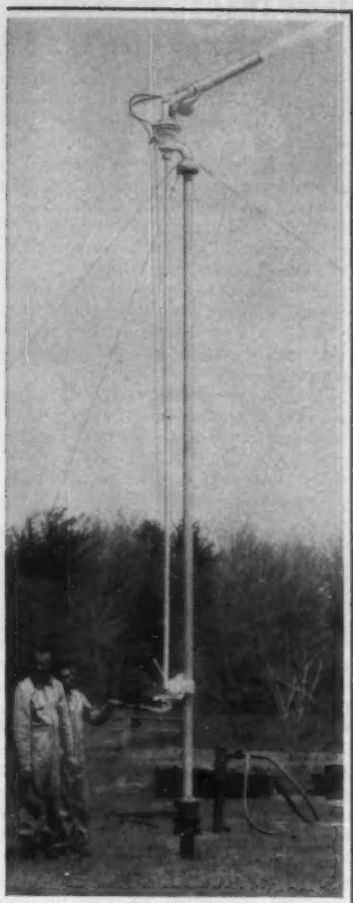

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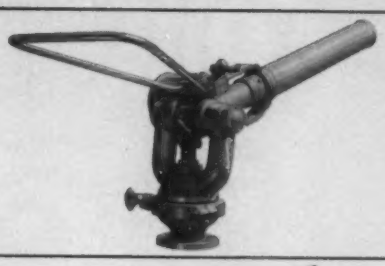

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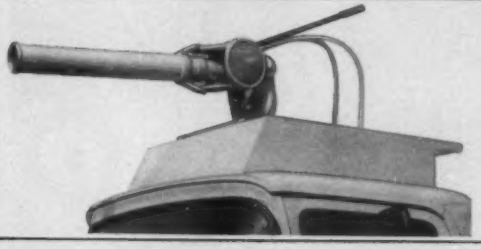
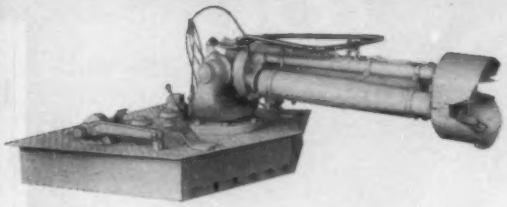
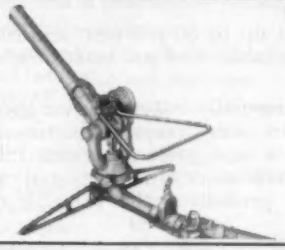


Remote Manual Control Type — Easily handled by man in driver's seat. Ideal for fast action!



Remote Hydraulic Control Type — Power-controlled from within the cab. Single and dual models. Widely used on air crash rescue fire-fighting trucks.



Portable Type — Off the truck and into action in seconds! Goes wherever a fire fighter can bring the proper hose line into action!

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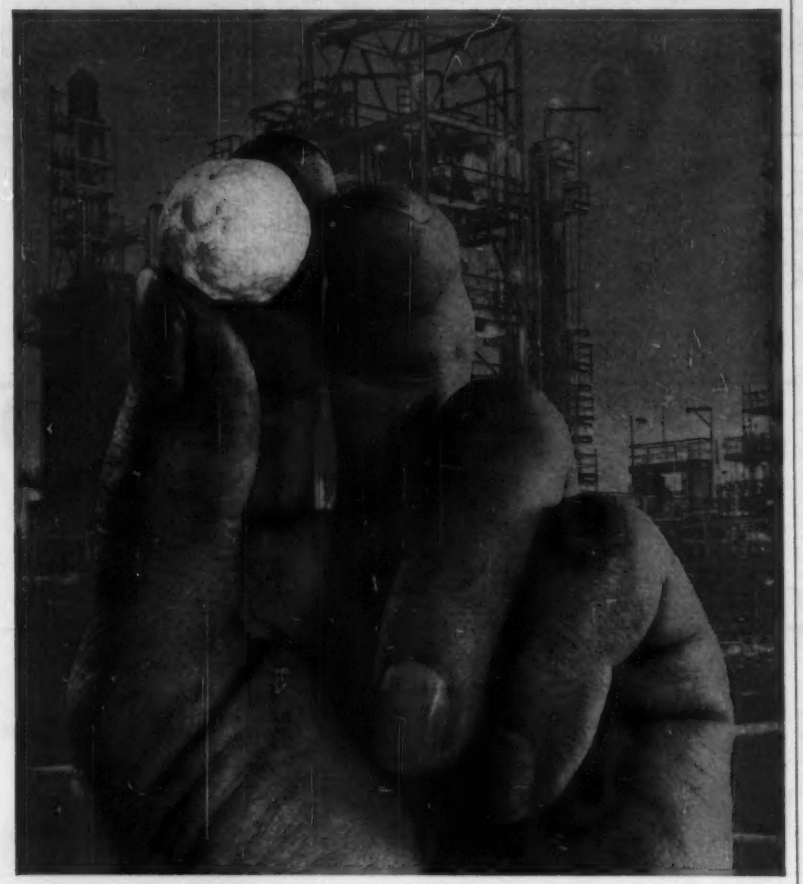

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Happenings . . .

Coal demand will also rise, according to Scott, but at only 1.4 percent per year contrasted with its recent decline of 2.9 percent annually. Salvati predicted a 500-million-ton-per-year demand for coal by 1963.

Urges That Technical Data Be Kept Away from U.S.S.R.

O. V. Tracy, vice president of Esso Standard Oil Co., urged those attending a recent Manufacturing Chemists' Association meeting help U.S. industry keep its technological processes and equipment out of the Soviet Union's hands. "And we must continue to urge our allies to reject deals designed to strengthen the Soviet industrial machine," Tracy added. He said Russians had tapped U.S. advanced technology in the 1930s, thus gaining "years in economic development. As soon as they got what they wanted, trade with the outside world was cut off practically overnight."

The same thing seems likely to happen now, Tracy said. He called attention to a statement by Russian leaders that trade is valued by the USSR mostly for political reasons, and that recent experience by Yugoslavia and Israel showed this to be true.

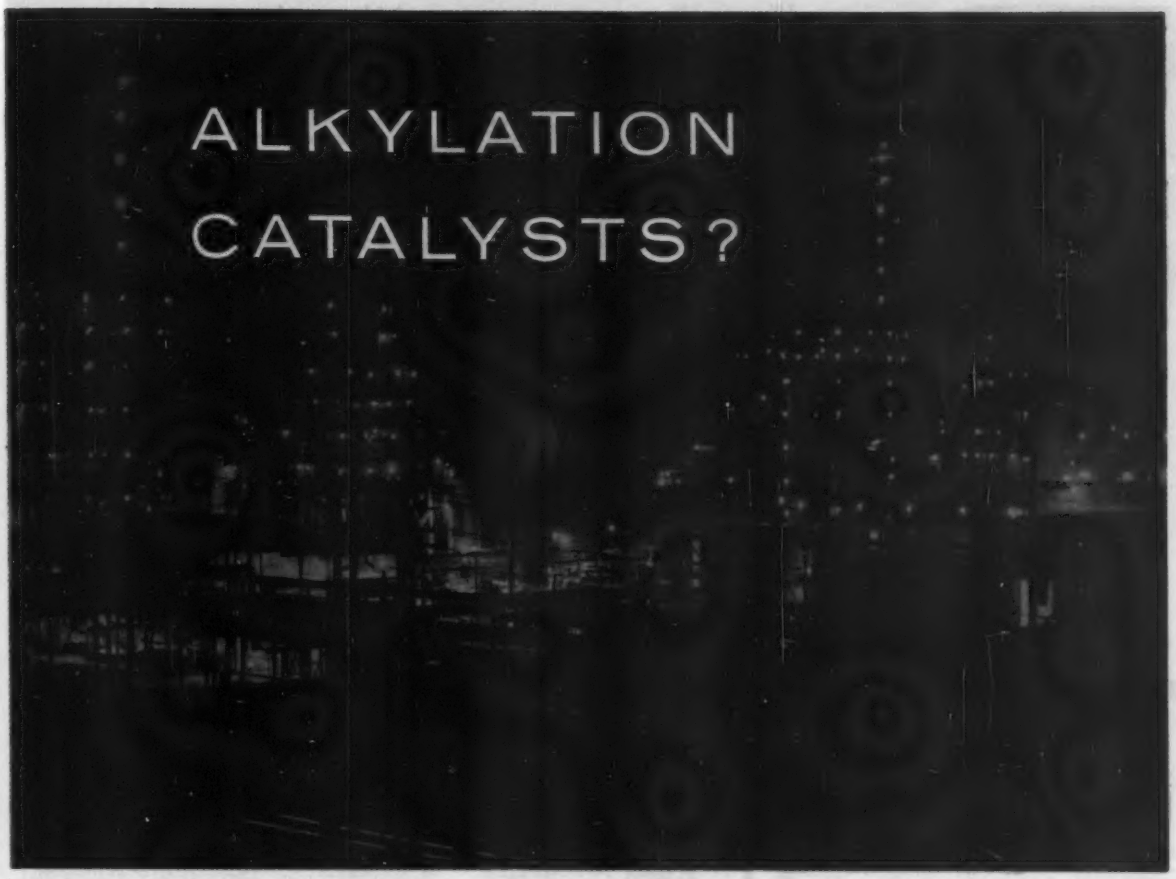
Approves Name Change For Junior Award to Authors

Council of the AIChE has approved changing the name of its Junior Award to the Allan Philip Colburn Award in honor of the late provost of the University of Delaware. The Award, first conferred in 1945, is given annually to the author or authors of an outstanding paper published by the Institute, provided the author is a member or associate member of AIChE and has not reached his 35th birthday anniversary. Dr. Colburn was a member of the University of Delaware staff from 1938 until his death in 1955. He was acting president of the University from April 1, 1950 until November 1950 and was named provost upon the arrival of President John A. Perkins.

Atomic Energy Fuels By '68 Predicts Retired Oil Exec

Atomic energy will become an electric power fuel competitor of oil in high-cost areas of the United States about 1968, predicts Robert E. Wilson, retired chairman of Standard Oil Co. (Indiana). Atomic power will become economic in England and one or two other European countries somewhat sooner than it will in the United States, and in most other industrial countries within eight or ten years, he said.

But once these other countries have atomic power plants, they'll develop somewhat more rapidly because the cost of conventional fuels don't vary as much in different parts of country. In the United States, he said, the pattern will



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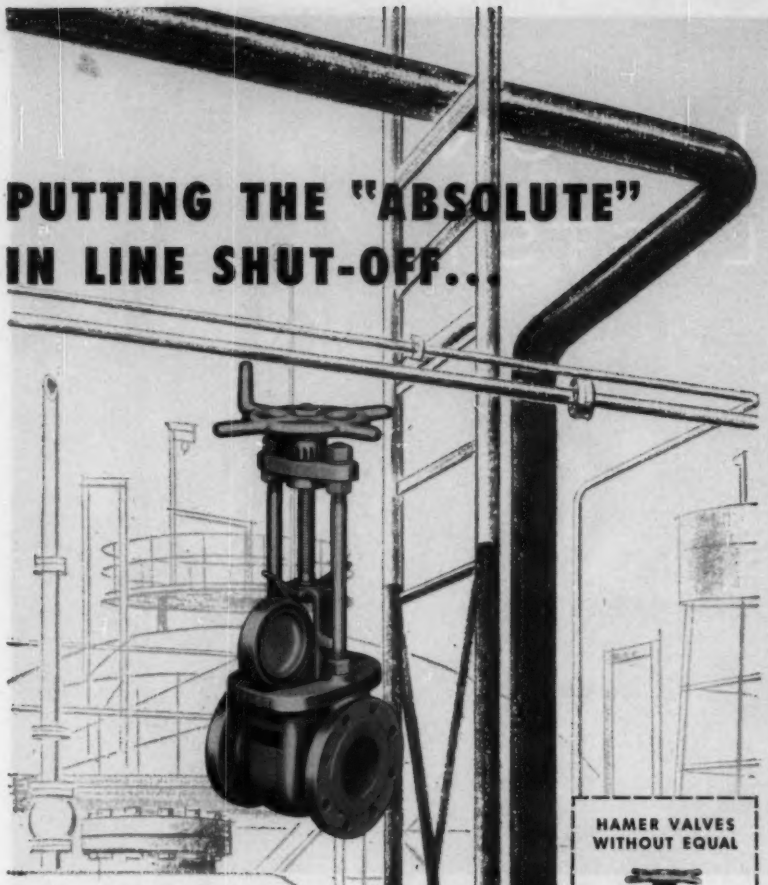

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Happenings . . .

likely be that power plants will continue to operate on conventional fuels for many years after atomic fuel plants become economic in some areas. Wilson, a member of the general advisory committee to the U.S. Atomic Energy Commission, concluded that atomic energy is likely to have a negligible impact on the petroleum industry during the next few decades.

Soviet Crude Production Up for First Half of 1959

Soviet crude oil production for the first half of 1959 exceeded the goal under Seven-Year Plan, and was up 14 percent from its corresponding 1958 period to 61.7 million tons, according to government spokesmen. Gas production was "somewhat short" of the target at 17.5 million cubic meters (about 618,012 Mcf), but 25 percent greater than in the first half of 1958. What Soviets described as "oil equipment" without elaborating was also reported as "somewhat short" of goal, totaling 39,300 tons, but up 11 percent. Similarly, manufacture of chemical equipment was reported short of target, but higher by 33 percent. Output was valued at 684 million rubles.

U. S. Crude Consumption For August Up From July

Domestic crude to be consumer in U.S. or exported in August has been estimated by Bureau of Mines at 6.92 million bpd, compared with 6.96 million for July. The forecast includes estimates of total gasoline demand of 4.3 million bpd in August; gasoline yield of 44.9 percent; and total crude runs of 7.8 million bpd. The Bureau of Mines said runs to stills in June "were higher than necessary." Reduction in gasoline stocks for June averaged 229,000 bpd, compared with a decline of 297,000 bpd in June, 1958. "From the current level of gasoline and distillate fuel oil inventories, it does not appear that crude runs to stills for the month of August will follow the usual seasonal trend upward, but will remain at about the same rate as forecast for July," the Bureau said.

Use of Coal Declining In Great Britain

The British Purchasing Officers Association said inland coal demand in Britain declined by 10 million tons in 1958, compared with 1957, while demand for oil in applications where coal could be used showed a rise between 1956 and 1958 of 8 million tons coal equivalent. "A heavy body blow also was dealt the coal industry," the association said, "on the introduction of the Clean-Air Act, with its consequent dent in the sales of household coal. It also appears that a radical change from the old conservative ways must be affected if coal is to exist as a serious challenge to oil and nuclear energy in ten years' time."

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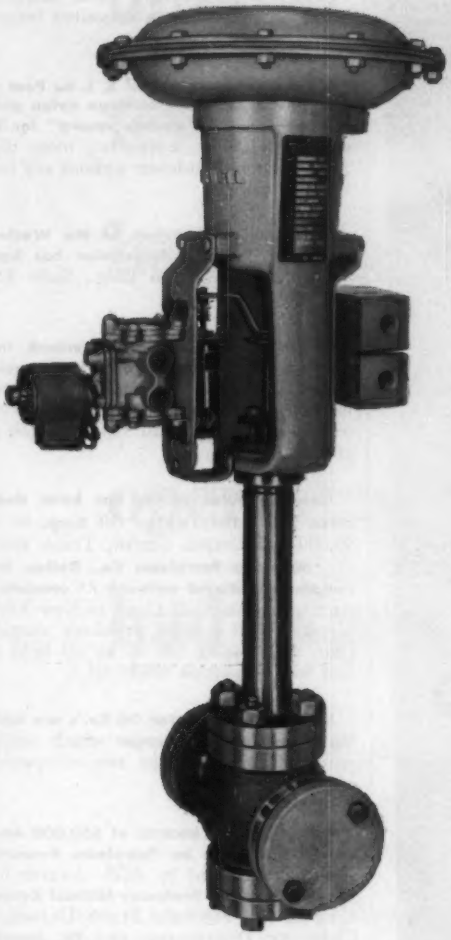


Honeywell control valves are available for a wide range of temperatures

Whether you're concerned with minus 450 or 1200°F, there's a Honeywell automatic control valve for your process flow. The Honeywell valve illustrated—Series 800, Type 12 single seated—is designed for liquid oxygen service. Thoroughly degreased and sealed, it includes such features as: bronze bushings . . . stainless steel body and trim . . . seal-welded seat ring . . . low-temperature bolting . . . non-lubricated, Teflon-impregnated, blue asbestos packing . . . designed clearances for non-sticking, non-galling operation.

For hot or cold flows . . . or other process flow conditions . . . Honeywell valves are available in a wide range of types and sizes. When you need control valves . . . contact your local Honeywell field engineer. Write for new Catalog C800-1.

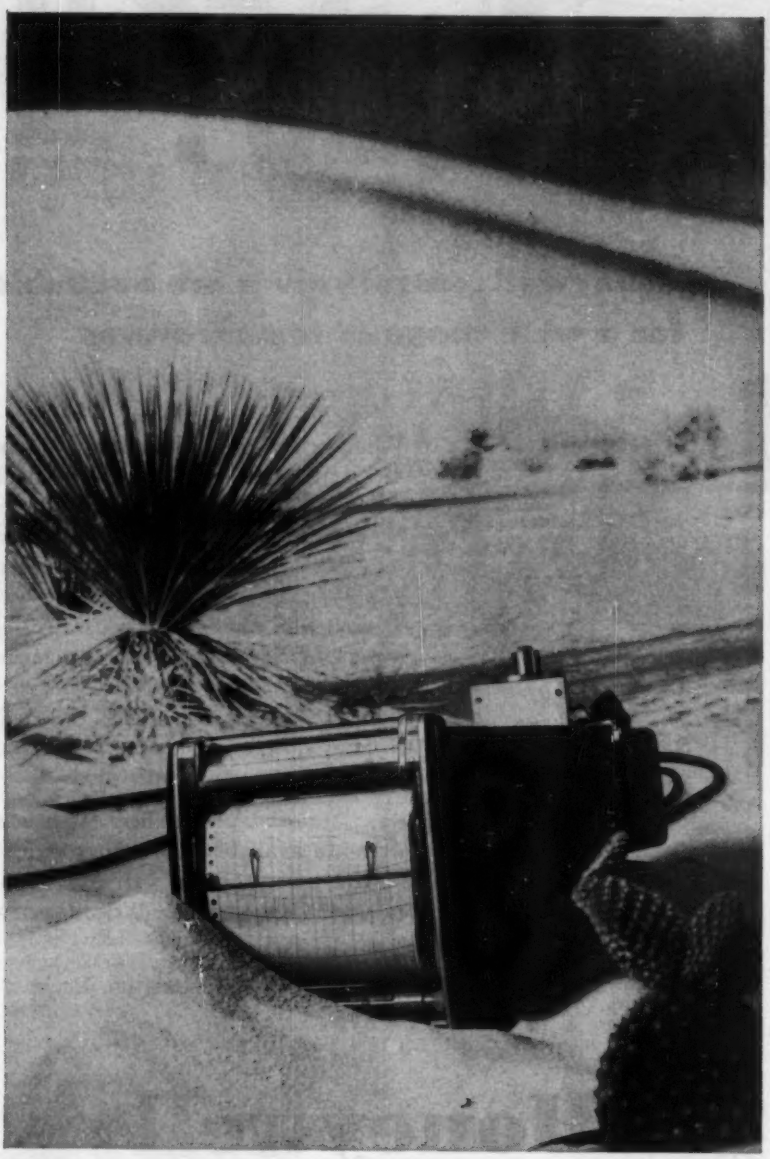
MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.

Honeywell

H HONEYWELL *First in Control*

For more data on advertised products, use Readers' Service Cards, last page.

KEEP YOUR INSTRUMENT AIR LINES DESERT-DRY... Get Lectrodryer—it costs you *less* to pay *more*. When product quality hinges on the performance of sensitive pneumatic instruments, it doesn't pay to skimp on instrument protection. Lectrodryers give you *proved drying ability*, plus long-range dependability, and that's why they cost somewhat more. They are designed generously; materials are of the best. Ask about the new Lectrodryer Budget Dryer. It's built especially for instrument service, when small quantities of air are required. Other standard Lectrodryers are available for larger volumes. Contact Pittsburgh Lectrodryer Division, McGraw-Edison Company, 307 32nd Street, Pittsburgh 30, Pennsylvania.



Lectrodryer® McGRAW EDISON

–Changing Times–

Responding to industrial interest in Government's proposed experiment with nuclear explosives in underground oil-shale deposits of West, **Bureau of Mines plans inviting petroleum and chemical producers to meeting for further discussion of proposal.** Time and place have not been determined.

Armour Chemical Division has signed manufacturing agreement with Chemical Developments of Canada, Ltd. Latter will produce many chemicals Armour previously supplied from United States.

Sunray Mid-Continent Oil Co. has acquired 90 percent of the stock of Suntide Refining Co., Corpus Christi, Texas. The offer to exchange one share of Sunray common stock for each three shares of Suntide common stock deposited became effective July 23.

The 2,500 employes of **E. I. du Pont de Nemours & Co.'s Chattanooga nylon plant established new "world's record" for industrial safety** by amassing more than 28.75 million man-hours without any lost-time injuries.

National Headquarters of the Western Petroleum Refiners Association has been moved to the Beacon Bldg., Suite 416, Tulsa.

World's first projected supertank terminal has been dedicated at Los Angeles Harbor. Union Oil Co. of Calif.-operated facility is operated by one man from control board—will unload 35,000 barrels of crude per hour.

New computer center has been dedicated by Delhi-Taylor Oil Corp. at its 40,000-bpd Corpus Christi, Texas, refinery. **Magnolia Petroleum Co., Dallas, has completed national network of computers** stretching from Gulf Coast to New York. Network will handle problems ranging from determining life of an oil field to best way to process crude oil.

Skelly and Tidewater Oil Co.'s are talking of proposed merger which would unite all phases of the two companies' operations.

Three research awards of $50,000 each have been made by Petroleum Research Fund, administered by ACS. Awards for use in 1959 go to **Professor Michael Kasha,** head of the Florida State University Chemistry Department, and **Dr. Harold Hart,** professor of chemistry, Michigan State University. **Professor S. I. Weissman,** Washington University, St. Louis, gets third award, for 1960.

Formation of **company to make polyethylene film and film products in Hawaii** involves Pacific Chemical and Fertilizer Co., Honolulu, and The Dow Chemical Co., of Midland, Mich. **Firm, to be known as Hawaiian Extruders, Inc., will locate in Honolulu.**

A LETTER FROM SOHIO TO M. W. KELLOGG

"We are well pleased with the performance of this integrated unit. It has performed with fewer startup troubles than we had anticipated, and it has demonstrated considerably more operating flexibility than we had expected..."

(Signed) **F. J. SANDERS, Engineering Manager**
The Standard Oil Company (Ohio)
Cleveland, Ohio

The above is an excerpt from the letter of acceptance from The Standard Oil Company (Ohio) to The M. W. Kellogg Company for SOHIO's recently dedicated 60,000 BPSD refinery at Toledo. Kellogg is privileged to have been able to work with Dr. Sanders and the many others at SOHIO in making this highly integrated $40 million refinery an economic success. For those wishing to obtain the complete story on the project, write Kellogg for the SOHIO Kelloggram—a 20-page booklet devoted to the refinery's engineering, construction, and operation.

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17, N. Y.
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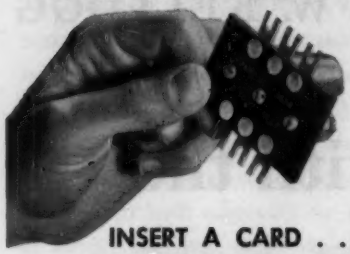
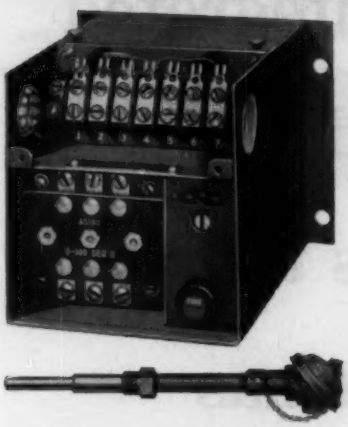
For more data on advertised products, use Readers' Service Cards, last page.

Great things are happening in AutroniC® Control



INSERT A CARD . . . CHANGE THE RANGE



LOW-COST, HIGH-PERFORMANCE ELECTRONIC RESISTANCE THERMOMETER

Pick a temperature range between —50° and 700°F., or —50° and 350°C.; place the corresponding range card in the Swartwout thermometer adapter, and the temperature range is set up, ready to go.

Simple? You bet. Simplified design is the reason for the low price of the Swartwout Resistance Thermometer. It is also the reason for the unit's exceptional dependability.

Highly sensitive, the fully-electronic Swartwout Resistance Thermometer temperature system is adaptable to full-scale temperature spans as small as 3°F. It can indicate, record, or control. With slight modification, or auxiliary equipment, it will add, subtract or average temperature . . . even control the ratio between two temperatures, or between temperature and another variable.

All this is done with electronic speed. Data is transmitted instantaneously . . . no time-lag no matter where temperature elements are located.

The operational ease, functional flexibility and simplicity of the Resistance Thermometer are characteristic of the entire line of Swartwout AutroniC Instrumentation.

For details on the Resistance Thermometer, request Bulletin A-706-B. The Swartwout Co., 18511 Euclid Avenue, Cleveland 12, Ohio.

SWARTWOUT

. . . world leader in electronic process instrumentation

S.A. 1909

Meetings Calendar

Aug.	
23–26	**American Institute of Electrical Engineers,** Petroleum Industry Electrical Conference, Wilton Hotel, Long Beach, Calif.
Sept.	
2– 4	**Cryogenic Engineering Conference,** University of California, Berkeley.
9–10	**American Society of Mechanical Engineers,** International Congress on Air Pollution, New York.
13–18	**American Chemical Society,** National Meeting, Atlantic City.
16–18	**National Petroleum Association,** Annual Meeting, Traymore Hotel, Atlantic City.
17	**Natural Gasoline Association of America,** Rocky Mountain Regional Meeting, Gladstone Hotel, Casper.
20–23	**ASME,** Petroleum Mechanical Engineering Conference, Rice Hotel, Houston.
21–23	**Workshop on Use of Passive Element Analog Computers in Oil Work Refinery Research,** Columbia University, New York.
21–25	**Instrument Society of America,** Annual Instrumentation-Automation Conference and Exhibit, International Amphitheater, Chicago.
22–24	**Industrial Nuclear Technology Conference,** Morrison Hotel, Chicago.
23–24	**Western Petroleum Refiners Association,** Rocky Mountain Technical-Industrial Relations Meeting, Henning Hotel, Casper.
27–30	**American Institute of Chemical Engineers,** Meeting, Hotel St. Paul, St. Paul.
28–30	**American Oil Chemists Society Meeting,** Hotel Statler, Los Angeles.
29–30	**WPRA,** Management Seminar, Western Hills Hotel, Wagoner, Okla.
28–Oct 1	**American Welding Society,** Fall Meeting, Sheraton-Cadillac Hotel, Detroit.
29–Oct 1	**National Association of Corrosion Engineers,** Western Region Conference, Bakersfield Inn, Bakersfield, Calif.
30–Oct 1	**Institute of Radio Engineers and AIEE,** Industrial Electronics Symposium, Mellon Institute, Pittsburgh.
Oct.	
1– 2	**NACE,** Southeast Region Conference, Jacksonville, Fla.
5– 8	**NACE,** Northeast Region Conference, Lord Baltimore Hotel, Baltimore.
7– 8	**WPRA,** Annual Stream Pollution and Waste Disposal Conference, Broadview Hotel, Wichita.
8– 9	**California Natural Gasoline Association,** Fall Meeting, Huntington-Sheraton Hotel, Pasadena, Calif.
11–16	**American Society for Testing Materials,** Pacific Area National Meeting, Sheraton-Palace Hotel, San Francisco.
12–14	**National Electronics Conference,** Hotel Sherman, Chicago.
20–22	**American Standards Association,** National Conference on Standards, Sheraton-Cadillac Hotel, Detroit.
20–22	**ASME-ASLE,** Lubrication Conference, Sheraton-McAlphin, New York.
20–22	**NACE,** North Central Region Conference, Cleveland.
23	**NGAA,** Southern Regional Meeting, Carlton Hotel, Tyler, Texas.
26–28	**National Lubricating Grease Institute,** Annual Meeting, Roosevelt Hotel, New Orleans.
28–29	**Computer Applications Symposium,** Morriston Hotel, Chicago.
28–29	**WPRA,** Question and Answer Session on Refining Technology, Rufus Garrett Hotel, El Dorado, Ark.
28–30	**Society of Automotive Engineers,** National Fuels and Lubricants Meeting, La Salle Hotel, Chicago.
30	**AIChE,** South Texas Section Technical Meeting, Moody Center, Galveston, Texas.
Nov.	
4– 6	**Institute of Radio Engineers,** National Automatic Control Conference, Sheraton Hotel, Dallas.
9–11	**American Petroleum Institute,** Annual Meeting, Conrad Hilton, Palmer House, and Congress Hotels, Chicago.
11–13	**National Fire Protection Association,** Fall Conference, Hotel Fort Des Moines, Des Moines.
17–18	**WPRA,** Computer Conference.
20	**NGAA,** Panhandle-Plains Regional Meeting, Herring Hotel, Amarillo.
29–Dec4	**ASME,** Annual Meeting, Chalfonte Haddon Hall, Atlantic City.
30–Dec4	**Exposition of Chemical Industries,** New York Coliseum.
Jan. 1960	
22	**NGAA,** Gulf Coast Regional Meeting, Robert Driscoll Hotel, Corpus Christi.
Feb.	
1–5	**ASTM,** Committee Week, Hotel Sherman, Chicago.
26	**NGAA,** Permian Basin Regional Meeting, Lincoln Hotel, Odessa, Texas.
March	
14–18	**NACE,** Annual Meeting, Memorial Auditorium, Dallas
18	**NGAA,** Oklahoma Regional Meeting, Biltmore Hotel, Oklahoma City.
April	
19–21	**Southwestern Gas Measurement Short Course,** Drill Hall, North Campus, University of Oklahoma.
20–22	**National Petroleum Association,** Semiannual Meeting, Hotel Cleveland, Cleveland.

Cut mixer maintenance cost as much as 60%

. . . specify LIGHTNIN Mixers with this leakproof seal

This mechanical seal can save you up to 60% of what you'd expect to spend on annual upkeep of a side-entering mixer on a big blending tank.

It *never* needs adjustment—runs for years without attention. It eliminates all the costly maintenance of a packed stuffing box.

At the same time, it positively stops troublesome drip, drip, drip—prevents waste of product and gives you clean, safe housekeeping around the tank.

And, when the seal finally does wear out, it's easy to replace—just a simple cartridge unit. One man can do the job easily and quickly, even with a full head of liquid in the tank.

There are no loose seal parts you have to assemble—no delicate adjustments to make. The cartridge is easy to stock as a spare. Or you can get a new one from MIXCO in a hurry when you need it. The seal is made in all sizes, and in materials to suit the simplest or toughest mixing conditions.

Biggest surprise of all is the price. A seal-equipped LIGHTNIN Mixer costs only a few dollars more than one equipped with a packed stuffing box.

Refiners everywhere are saving thousands of dollars yearly on mixer maintenance with this exclusive LIGHTNIN Mixer feature. To learn how inexpensively *you* can use it to build low-cost upkeep into your big blending tanks, call in your LIGHTNIN Mixer representative today. He's listed in Refinery Catalog. Or write us direct.

For simplest possible maintenance, you can get LIGHTNIN Side Entering Mixers in a wide choice of corrosion-resistant materials, with gear drive or V-belt drive, and with mechanical seals or stuffing boxes to meet every service condition.

"Lightnin' Mixers"

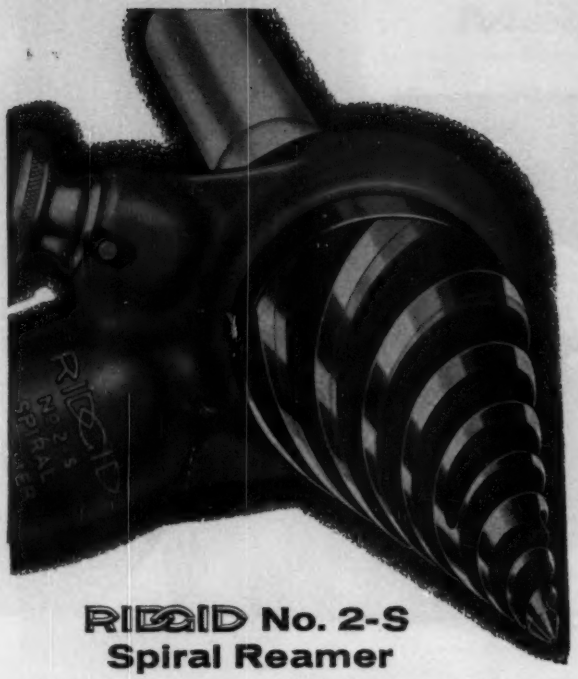
MIXCO fluid mixing specialists

- ☐ Send us the cost-cutting facts on LIGHTNIN Rotary Mechanical Seals—Bulletin B-111. We'd also like catalog information on these LIGHTNIN Mixers:
- ☐ Side entering: 1 to 25 HP (B-104)
- ☐ Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP (B-102)
- ☐ Top entering propeller types: ¼ to 3 HP (B-103)
- ☐ Portable: ⅛ to 3 HP (B-108)
- ☐ Laboratory and small-batch production types (B-112)
- ☐ Condensed catalog showing all types (B-109)
- ☐ Data sheet for figuring mixer requirements (B-107)

Check, clip and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 164-h Mt. Read Blvd., Rochester 3, N.Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.



RIDGID No. 2-S
Spiral Reamer

⅛" to 2" Capacity... Self-Feeding for Least Effort

For Smooth, Easy Reaming it has to be

RIDGID

No. 2
⅛" to 2" Capacity

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"LonGrip"
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No Thinned or Flared Walls

Take your choice—Spiral or "LonGrip"—you can't beat these RIDGID Reamers. For hand reaming, you probably prefer the effortless self-feeding Spiral; for power use, the "LonGrip" five-fluted reamers. Heat-treated cutting edges offer extra-long service . . . will not dig in and thin or flare walls. All RIDGID Ratchet Reamers come equipped with handle.

Your Supply House has them. For smoother, faster reaming, order yours today.

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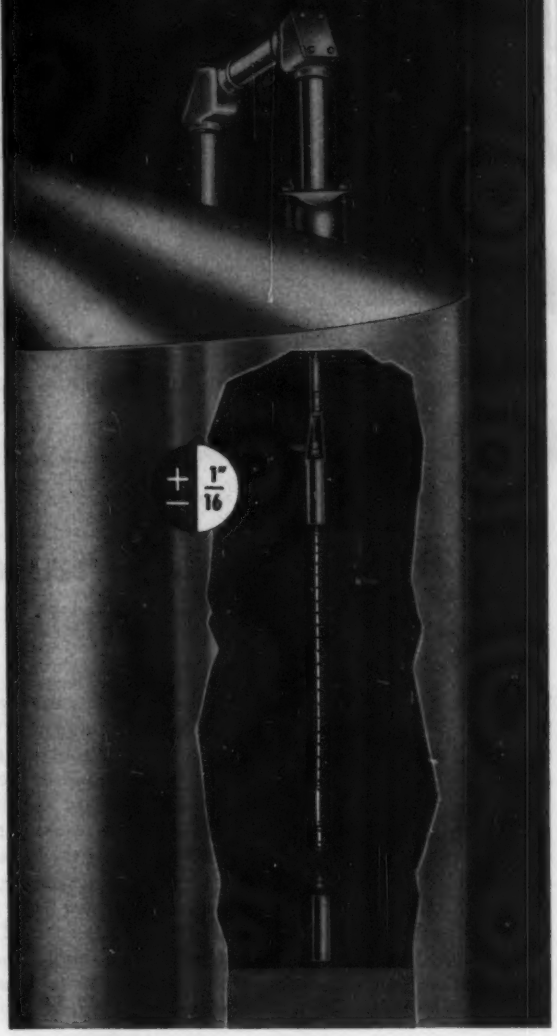
NOW COMPLETE AUTOMATION IN TANK GAUGING!



You can eliminate hand gauging completely with the new Gilbarco electronic Tank Gauge because this gauge measures *both product level and water interface.* At the turn of a switch the sensing element, which tracks product level, will penetrate the product to also measure water bottom. Readings of both levels can be made at the tank base or remotely on a Gilbarco Null-Balance Receiver. Gauges already installed can be equipped for this dual operation quickly, easily, inexpensively. Write for full information on the *only* gauge which gives you complete gauging automation.

Gilbarco

Gilbert & Barker Manufacturing Co.
West Springfield, Mass.
Toronto, Canada

Men In Industry...

Union Oil's K. C. Vaughan Named New CNGA President

California Natural Gasoline Association has named **K. C. Vaughan** president. Vaughan, manager of the Natural Gasoline and Gas Department, Union Oil Co. of Calif., accepted the gavel from **H. J. Maxwell,** Standard Oil Co. of Calif., the retiring president. **J. A. Smith,** superintendent of gas and gasoline plants, Texaco, Inc., took office as vice president and advisory committee chairman.

Newly elected to the Board of Directors for a two year term were: **J. B. Armstrong,** Standard Oil Co. of Calif.; **D. R. Arnold,** Signal Oil & Gas Co.; **L. E. Clasen,** Richfield Oil Corp., **Les Gfeller,** General Electric Co.; **F. H. Lacy, Jr.,** Honolulu Oil Corp.; **Milton Lewis,** Ralph M. Parsons Co.; **Harvey Menard,** Signal Oil & Gas Co.; **D. E. McFaddin,** Union Oil Co. of Calif. and **E. P. Valby,** Richfield Oil Corp.

E. R. Millett, Jr., was reappointed secretary-treasurer of the association.

K. C. Vaughan

Richard D. Burt has been named technical staff assistant; **James J. Honan,** general operating foreman; and **Bruce G. Hawthorn,** technical assistant for Sun-Olin Chemical Co., North Claymont, Del. Burt joined Olin Mathieson in 1957 as a staff assistant for organic chemicals. Last year he was transferred as staff assistant to the corporation's petrochemical plant at Brandenburg, Ky. Honan began his career with Sun as a laboratory tester in 1930. He was promoted to foreman in March, 1954, the position he held prior to his new appointment. Hawthorn has served in technical service at Sun's Marcus Hook refinery since 1954.

W. R. Wyatt has been named superintendent of Shell Oil Co.'s Weeks Island, La., natural gas and processing plant. He previously was assistant plant superintendent of the Sheridan, Texas, cycling plant. Holder of a B.S. degree in chemical engineering from The University of Texas, Wyatt joined Shell as a junior gas engineer at Sheridan in 1948.

Benjamin G. Jones has been appointed supervisor of the Research Section at Tidewater Oil Co.'s Avon refinery near San Francisco. He previously held managerial and supervisory positions, the most recent being as assistant to the Delaware refinery manager.

Robert N. Simonsen of The Standard Oil Co. (Ohio) has received the newly established F. H. Waring Award of the Ohio Sewage and Industrial Wastes Treatment Conference. This award will go annually to an industrial member of the conference based on his activity in the organization and for the administration of an industrial waste treatment program, or for research and development in analytical or treatment technology, or for outstanding operation of an industrial waste treatment facility. Simonsen coordinates The Standard Oil Co. (Ohio) current and long range program of pollution control work for both air and water.

J. D. Nitzschke has been named superintendent of American Oil Co.'s terminal at Providence, R. I., and **R. G. MacLean** superintendent of the Portland, Me., terminal. Nitzschke was formerly associate civil engineer at the El Dorado, Ark., refinery, and MacLean was assistant superintendent of the Portland Terminal.

J. W. Bartlett, vice president, Special Projects Division, Delhi-Taylor Oil Corp. has retired. A 35-year veteran in petroleum, he joined Delhi in 1949 and was elected vice president of engineering in 1950. In 1957 he became vice president, Special Projects Division.

James McDonald has been named assistant general manager of Tidewater Oil Co.'s Western Division and **Clifford A. Phillips** has been named to succeed him as administrative manager of manufacturing. Both will headquarter in Los Angeles. McDonald has been with Tidewater since 1940 and Phillips joined the company in 1950.

Robert H. Ossyra has been named a group leader at the Seymour, Ind., laboratories of the Research and Development Department, Standard Oil Co. (Indiana). He will head a group in developing new solid propellants and the equipment used with them.

Dr. R. T. Moravek has been named senior research chemist in Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas. He is engaged in analytical research utilizing colorimetry and spectrophotometry. Dr. Moravek has a B.S. degree in chemistry from St. Ambrose College and M.S. and Ph.D. degrees from Louisiana State University.

J. R. Barsalou has been named operations manager at Humble Oil & Refining Co.'s Baytown, Texas, refinery. He is responsible for the Process, Operating Services, and Maintenance and Construction Divisions. Barsalou has been general foreman, light oil treating, and assistant head, Coordination Division, Baytown Refinery. For a year he was technical assistant to the manager of manufacturing, Houston.

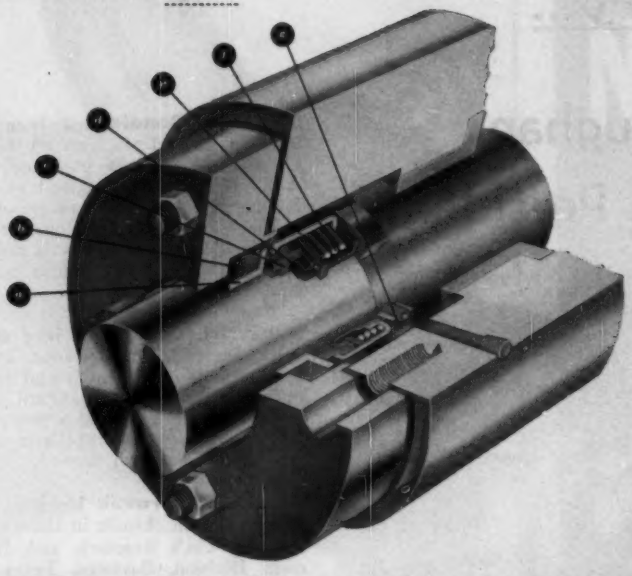
Gene F. Metzinger has been named Western District Manager for Shell Chemical Corp's. new Plastics and Resins Division. He joined Shell Chemical after receiving a B.S. degree in chemistry from the University of Illinois in 1949.

D. R. Moore has been promoted to senior chemical engineer in the Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery. Currently head of the Catalytic Cracking Section, Moore holds a B.S. degree in chemical engineering from The University of Texas.

John M. Luger has been named assistant to the executive vice president of Jefferson Chemical Co., Inc. His major responsibility will be the preparation of studies on the various areas of management. Luger joined Jefferson in 1955 as administrative assistant to the sales manager.

Thomas C. Barger has been elected president of Arabian American Oil Co. **Norman Hardy,** president since January, 1958, has been elected chairman of the board of directors. He will continue as chief executive officer. Also elected to the board was **John Noble,** president of

ONE OF THE GARLOCK **2,000**



GARLOCK Mechanical Seals —self-contained for easy installation, less downtime

a. ***Stationary Seat*** *of ceramic, Ni Resist, or bronze has precision lapped sealing face for perfect contact with carbon ring.*

b. ***Vibration Ring*** *of Buna-N positions stationary seal in a flexible mounting and acts as static seal.*

c. ***Seal Ring*** *of carbon is also precisely lapped to match sealing face of stationary seal.*

d. ***Roll type Bellows*** *permits free movement of seal ring.*

e. ***Shell,*** *encases entire rotary unit and furnishes mechanical drive for seal ring.*

f. ***Stainless Steel Spring*** *with load precisely calculated to face area of seal.*

g. ***Stop Collar,*** *or shoulder, positions seal to specified operating length.*

Garlock's PK MECHANIPAK* is designed to avoid excessive downtime. Self-contained, it can be installed simply and quickly, and eliminates adjustment during operation. Seal life is equal to many sets of conventional packings. Check these additional advantages:

Leak-proof sealing. Sealing faces of rotating and stationary parts are precision lapped for perfect contact, thus preventing leakage.

Elimination of shaft wear. No parts of the seal move on the shaft or sleeve, thus removing the danger of scoring or wear.

Maximum operating conditions are 212° F temperature, 150 psi pressure, 2000 fpm shaft speed. Available in shaft sizes from $\frac{3}{8}$" to 3", PK MECHANIPAK Seals are another of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. Find out more by talking with your local Garlock representative, or write for Catalog AD-150.

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GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

CANADIAN DIVISION: The Garlock Packing Co. of Canada Ltd.
PLASTICS DIVISION: United States Gasket Company

Men . . .

Trans-Arabian Pipe Line Co. Barger joined Aramco as a geologist in 1937. Hardy was president of Richmond Exploration Co. before joining Aramco in 1951. Noble was associate general counsel of Aramco before becoming president of Tapline in 1956.

Kelso

Souby

E. A. Kelso has been named a senior research specialist for Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas. **A. M. Souby,** has been appointed a section head, **C. Phillips** a research specialist and **T. S. Farmer** a senior research chemical engineer.

James A. Christensen has been named manager of Standard-Vacuum Oil Co.'s Economic Coordination Department, White Plains, N.Y. He joined Stanvac in 1953 as assistant manager of the department, having previously served 25 years with Esso Standard Oil Co. in New Jersey. Christensen has a B.S. degree in mechanical engineering from Cooper Union, and took postgraduate work in chemical engineering at Columbia University.

Christensen

Frank M. Gibbons has joined Commonwealth Services Inc., as supervisor of oil refining and petrochemical consulting activities. He will be stationed in the company's Houston office. Formerly a project manager of refinery engineering and construction for Fluor Corporation, Ltd., he has also worked as a project engineer for Bechtel Corp. in a similar capacity. Gibbons holds a B.S. degree in mechanical engineering from Brooklyn Polytechnic Institute.

Gibbons

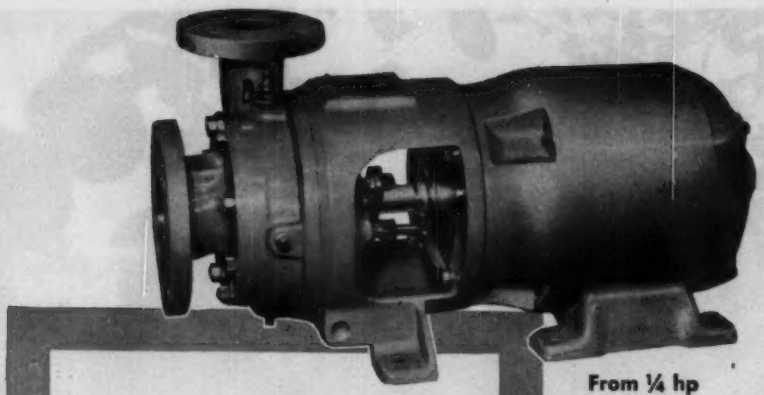
Vincent W. Suellau and Frank J. French have been named executive vice presidents of General Chemical Division, Allied Chemical Corp. With Allied

How an oilman at his desk protects the fruit of the land.

He is part farmer, part chemist, all oilman. He knows how to use oil-based insecticides to help keep farm produce free from destruction by aphids, nematodes, grasshoppers, mites and other hungry insects. He knows how important oil is to today's highly mechanized farms. He knows—and so do you. The next time you hear somebody speak out against oil—tell him you're an oilman and proud of it. And tell him why.

SHELL OIL COMPANY

For more data on advertised products, use Readers' Service Cards, last page.



From ¼ hp
to 75 hp

ready now
to solve your
pumping problems

Ingersoll-Rand MOTORPUMP

WHEN YOUR IMPORTANT PRODUCTION depends on proven pumping power, you need the efficiency and reliability of I-R Motorpumps! Low maintenance and minimum down-time mean cost-cutting operation that continues to pay off year after year.

I-R Motorpumps are always available in the widest range of types and sizes for every type of installation. Capacities from 5 to 2800 gallons per minute; heads to 650 feet.

Compact Motorpumps are easy to install. They operate in any position, save valuable floor space. Write today for specifications and performance data.

Ingersoll-Rand

9-827 11 Broadway, New York 4, N. Y.

Men . . .

Chemical 38 years, Suellau had been vice president in charge of sales, General Chemical Division, since 1954. Previously he was director of sales and sales manager of the division's industrial chemical products. French had been vice president in charge of the division's production, mining, purchasing, and industrial service activities for the past year. He was previously director of purchases, General Chemical Division, 1952-58.

Worthington

Van Ness

E. W. Van Ness and **Mark Worthington** have been elected vice presidents of The Ralph M. Parsons Co. Van Ness is manager of the Petroleum and Chemical Engineering Division and Worthington is manager of the Cost Engineering Division. Worthington joined Parsons in 1945 as chief estimator, while Van Ness came with the company in 1946 as a project engineer. Both have worked for other engineering and construction firms.

L. A. Lohman, administrative superintendent at Shell Oil Co.'s Wood River refinery, retired August 1. He will be succeeded by **V. G. Harrison,** administrative superintendent at the Norco, La., refinery. Lohman began his career with Shell in April, 1930, as manager of the Personnel and Industrial Relations Department, Wood River. In 1935, he was named assistant to refinery manager there. He was transferred to Shell's head office industrial relations department in 1941, and in 1943 became assistant manager of the department. He returned to the Wood River refinery in his present position in March, 1946.

Lohman

Drs. William A. Cunningham and Howard F. Rase, University of Texas chemical engineering professors, have been elected national officers of Omega Chi Epsilon. Dr. Cunningham was named president, and Dr. Rase was re-elected treasurer.

W. Alton Jones has been named chairman of the executive committee of Cities Service Oil Co., and **Burl S. Watson** chairman of the board and chief executive officer. **J. Ed. Warren** was

SPENT SULPHURIC ACID
SPENT SULPHURIC ACID
SPENT SULPHURIC ACID
SPENT SULPHURIC ACID
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SPENT H_2SO_4 that is!

There probably isn't a bigger headache in industry than spent sulphuric acid.

Yet it's a waste you can't afford to waste . . . and rarely afford to salvage yourself.

We suggest you turn it over to pro's with the world's largest facilities for regeneration of spent acid and delivery of water-white H_2SO_4.

Consolidated Chemical Industries handles any processable spent acid wastes from lube oil, naphtha, DDT, benzene, alkylation, alcohol, detergent and other processes . . . and you'll be surprised what we can handle!

What's more . . . you will get back virgin acid tailor-made to your process strength, accurate to 1/10th of 1%.

Give us a call if you have problems with Spent Sulphuric Acid.

Spent Acid regeneration plants at Houston and Baytown, Tex., Baton Rouge, La., Hammond, Ind., and Dominguez, Cal. Sulphuric Acid is also shipped from other plants at Fort Worth and Corpus Christi, Tex., LeMoyne, Ala., Vernon and Richmond, Cal., and Tacoma, Wash.

Stauffer CHEMICALS SINCE 1885

STAUFFER CHEMICAL COMPANY

380 Madison Avenue, New York 17, New York

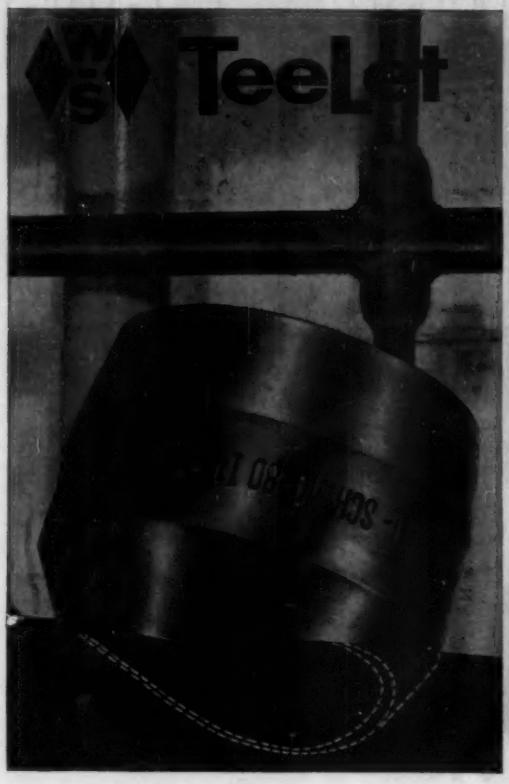
Prudential Plaza, Chicago 1, Illinois — 636 California Street, San Francisco 8, California

824 Wilshire Boulevard, Los Angeles 17, California — P. O. Box 9716, Houston 15, Texas

CONSOLIDATED CHEMICAL INDUSTRIES DIVISION, 6910 Fannin St., Houston 25, Texas

For more data on advertised products, use Readers' Service Cards, last page.

FOR ⅜ TO 1½ INCH BRANCH CONNECTIONS



MARK

CUT

WELD

NEW W-S TeeLet SLASHES TEE COSTS 50% OR MORE!

The new W-S TeeLet replaces conventional Tees of cast or malleable iron, welded or forged steel . . . requires fewer stock sizes. Available in sizes from ⅛ to 1½" IPS, TeeLets are fully machined from forging quality solid steel bars and adapt to run-pipe sizes to 36". They require no additional joint strength calculations for any ASTM A-53 or A-106 Grade B run-pipe of Schedule 40 or 80.

What about cost? A size-by-size comparison with conventional Tees shows TeeLets average less than 50 per cent of the cost you now pay. A W-S TeeLet, with screwed, socket-weld or butt-weld ends, requires no shaping, fitting, beveling or extra alignment. You can connect to the run-pipe at any point. Short heights mean easy inspection of the attachment weld or back-weld, if desired.

A W-S TeeLet costs less to buy, less to install than anything you can buy or make. For complete information, prices, and names of distributors, write: *Forge and Fittings Division, H. K. Porter Company, Inc., Box 95, Roselle, N. J.*

FORGE AND PORTER FITTINGS DIVISION

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION; Copper and Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

Men . . .

elected president. Three senior vice presidents elected are **A. P. Frame, Charles S. Mitchell** and **George H. Hill, Jr.** Two new vice presidents elected are **Erle G. Christian** and **Edward L. Stauffacher.**

Phillips

McDonald

James McDonald has been named assistant division general manager of Tidewater Oil Co.'s Western Division, and **Clifford A. Phillips** has been selected to succeed him as administrative manager of manufacturing. McDonald joined Tidewater in 1940 as junior process engineer at the company's former Bayonne, N. J., refinery. Phillips joined the company in 1950 as associate engineer at the former Drumright, Okla., refinery. Since 1956 he had been at the Delaware refinery oil manufacturing center as superintendent of crude distillation, fluid coking and catalytic cracking.

J. T. Higgins has been named vice president, director and general manager of manufacturing for Standard Oil Co. of Calif., Western Operations, Inc. He succeeds **Fred Powell,** recently named president and chief executive officer of California Chemical Co. Higgins will coordinate Standard's manufacturing activities at refineries in Richmond, El Segundo and Bakersfield, Calif., and at the new refinery under construction near Honolulu. A 1928 graduate of Stanford University, he joined Standard in 1929 as a specialist with its California Research Corp., El Segundo.

Higgins

John W. Miller has been appointed vice president of International Refineries, Inc., Wrenshall, Minn., in addition to his present duties as general manager. Miller joined International Refineries about a year ago and was recently appointed to the board of directors. Before joining International he was export sales manager for Creole Petroleum Corp., New York. He had also worked in a number of engineering

Miller

66 NO
INTO T
Tapping
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temporo

Offering yea

Temporary by-pass
STOPPLE Plugging Machine
STOPPLE (or existing valve)
Section of pipe for repair, replacement, modification, etc.

Machines also available on rental basis

"NO SHUTDOWN WHILE CUTTING INTO THE LINE with a WmSon-Hillco Tapping Machine. When the tap is completed, Williamson Stopples plug the line temporarily while the flow continues through a by-pass. You can make repairs, replace piping, connect process units and booster stations, install fittings, extend or abandon piping. It's all done without shutdown and **WITH COMPLETE SAFETY!"**

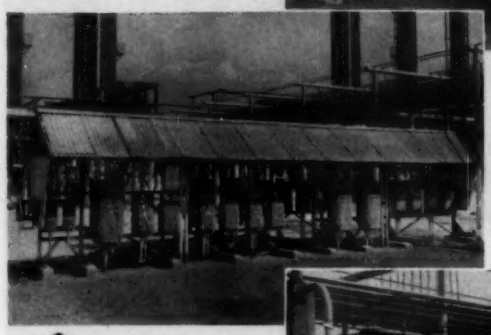
Offering years of research and experience in hot tap operations

T.D. Williamson, Inc.
P. O. BOX 40 TULSA 2, OKLAHOMA

REPRESENTATIVES AROUND THE WORLD

Right foreground: Nelson Class 1041, oil-immersed, 4160 volt motor starters

Left background: Nelson Class 497, factory-assembled switchrack, 480 volt



Nelson Class 497 switchrack with explosion-proof starters

Nelson 2000 KVA, double front, unit substation (explosion-proof)

Phillips Chemical Doubles Plant Capacity

Editors of a leading magazine recently published a six page article on how Phillips Chemical doubled the production capacity of its Plains Synthetic Rubber Plant. They told how it was done and stressed the importance of selecting quality equipment to assure a high degree of reliability. In addition to the equipment pictured Nelson furnished such vital equipment as motor control centers, explosion-proof circuit breakers, combination starters, control stations and lighting panels.

Nelson takes pride in building quality into every job. If you are looking for a source of electrical control equipment that puts pride of workmanship above all, may we suggest you contact your Nelson Sales Representative. Offices are located in principal cities throughout the United States.

P. S. If you would like a print of the article mentioned please send your request to the factory. It will be mailed promptly.

At Nelson . . . . *quality* comes first!

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

Men . . .

and managerial positions since 1934 with Standard Oil Co. of Louisiana, Baton Rouge, and Standard Oil Development Co., Bayway, N. J.

Haynes

Postgate

Donald F. Haynes, manager of Humble Oil & Refining Co.'s Crude Oil Department, has retired. He will be succeeded by **James C. Posgate,** who has been assistant manager of the department since January. Haynes started his service with Humble in 1918. Posgate joined Humble in 1933 in the Production Department, Gladewater, East Texas Division, and has since held a number of executive positions.

Dr. Guy Jorquera, a member of The Lummus Co.'s New York office Process Department, has received a gold medallion from the Chilean Institute of Chemical Engineers, of which he is the founder and the organization's first president. Mounted on a leather plaque, the medallion is inscribed "To our founder and first president 1933—with gratitude." Since 1944, Jorquera has been a member of AIChE, CIChE's American counterpart. He holds M.S. and Ph.D. degrees in chemical engineering from Oregon State University.

Jorquera

Charles B. Sipple has been named chief refinery engineer, Mobil Oil Co., East Chicago refinery. A graduate of Rose Polytechnic Institute, he was formerly assistant operating superintendent and held various other positions in the Operating Department during his 22 years with the refinery.

J. Howard Olehy has been elected vice president of Petroleum Chemicals, Inc. He was formerly general manager of manufacturing with New Orleans headquarters.

Shaikh Hafiz Wahba, Saudi Arabia's ambassador-at-large to the Arab world, and **Shaikh Abdallah H. Tariki,** the country's director general of petroleum and mineral affairs, have been elected to the board of directors, Arabian American Oil Co. Hafiz Wahba has had a long

*Patented
**Teflon
DuPont Trademark

NO LEAKAGE...

You're looking at the newest thing in valves...

STOCKHAM'S NEW WEDGEPLUG* "O-SEAL" VALVE

Two Teflon** "O" rings in the plug give constant vapor-tight shut-off... to give you double assurance of double savings on operating and maintenance costs.

NO LUBRICATION...

HOW TEFLON "O" RINGS WORK The two Teflon "O" rings are inserted in dovetail grooves machined on the face of the plug. These "O" rings seat on the raised body seats when the plug is in closed position.

CONSTANT VAPOR-TIGHT SHUT-OFF This sealing effect of the "O" rings gives absolute shut-off in all cases—shut-off that remains permanently "bubble tight." The Teflon "O" rings are chemically inert, practically frictionless, and will not cold flow.

TESTS PROVE POSITIVE SHUT-OFF

Hundreds of tests of this new valve in all types of services have failed to make it leak. Performance has been remarkable. In every case, the valve held "bubble tight" because of the pressure seal effect of the "O" rings.

OTHER OUTSTANDING ADVANTAGES

Non-Lubricated—no costly maintenance necessary • Provides Double-Block and Bleed in most services • Quick, Easy Operation—won't stick or bind • Double Seating for Double Safety—Ground metal-to-metal seat provides shut-off in case fire burns out "O" rings • No Product Contamination • Protected Seats

RECOMMENDED USAGES Stockham's new "O-Seal" is recommended for all general purposes—air, gas, water, steam, propane, hydrocarbons, etc., as well as for hard-to-hold services. Recommended for temperatures from minus 300°F to 400°F and not exceeding 720 psi.

Available in carbon and alloy steels, 2" - 12" sizes, 150 and 300 lb. pressures. Three port openings—40%, 70%, full round-wrench, handwheel, gear, and motor operated.

*Patented
**Teflon
DuPont Trademark

STOCKHAM'S NEW WEDGEPLUG "O-SEAL" VALVE

Call Your STOCKHAM Distributor or Sales Representative for complete details, or write today for the new brochure on the Wedgeplug "O-Seal."

Stockham makes a **BETTER** *valve...for* **EVERY** *job!*

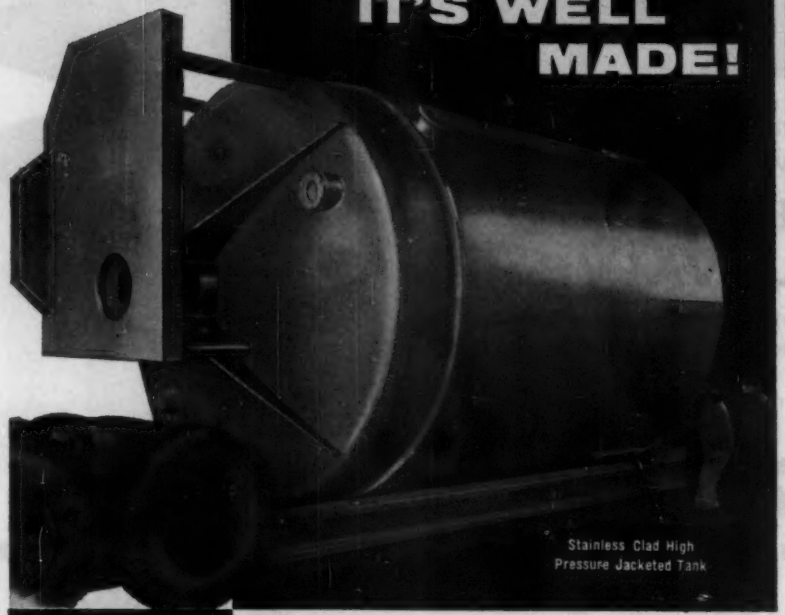
WEDGEPLUG VALVE COMPANY Division of →

STOCKHAM VALVES *and* FITTINGS

General Offices and Plant—4003 North 10th Avenue, Birmingham 2, Alabama

CAST IRON-MALLEABLE PIPE FITTINGS • BRONZE, CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES

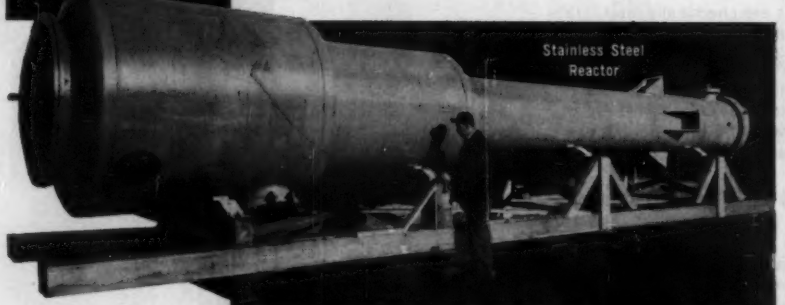
IF Koven MADE-
IT'S WELL MADE!



Stainless Clad High Pressure Jacketed Tank

FOR QUALITY CONTROL

- x-ray inspection.
- mass spectrometer testing.
- magnetic particle inspection.
- penetrant dye checking.



Stainless Steel Reactor

Koven equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks.

SPECIALISTS IN INTRICATE FABRICATION USING: STAINLESS STEEL · ALUMINUM · MONEL · NICKEL · INCONEL · ALL CLAD MATERIALS · NICKEL PLATED STEEL

Fabrication to all A.S.M.E. Codes

See Sweet's Catalog File and Chemical Engineering Catalog

Call or write for a consultation with a trained KOVEN representative and send for Bulletin #550

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STEEL PLATE FABRICATORS ASSOCIATION

Koven FABRICATORS, INC.

93-P East Dickerson Street, Dover, New Jersey

Men . . .

career in the diplomatic service of Saudi Arabia. Abdallah Tarika has been active in Arab League oil affairs and headed the Sudi Arab delegation to the First Arab Petroleum Congress in Cairo recently.

Powell

Shiffler

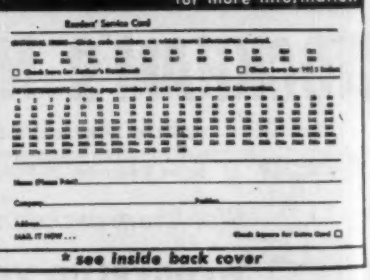
Fred Powell has been named to head Standard Oil Co. of Calif.'s activities in the chemicals field as president of California Chemical Co. He will have overall responsibility for Standard's chemical industry operations, with **W. H. Shiffler,** vice president. Powell has been vice president, Standard Oil Co. of Calif., Western Operations, Inc. Shiffler has been a vice president of California Research Corp. since 1945.

Lawrence C. Hamlin, executive development advisor, Standard-Vacuum Oil Co., has been appointed regional vice president, White Plains, N. Y., with responsibility for Far East operations. He will coordinate company interests in Japan, Korea, the Philippines, Hong Kong, Taiwan, Viet-Nam, Cambodia, Laos, Thailand, Malaya and Singapore. Holder of a B.A. degree from Hiram College and a B.S. degree from M.I.T. Hamlin joined Standard-Vacuum in 1936.

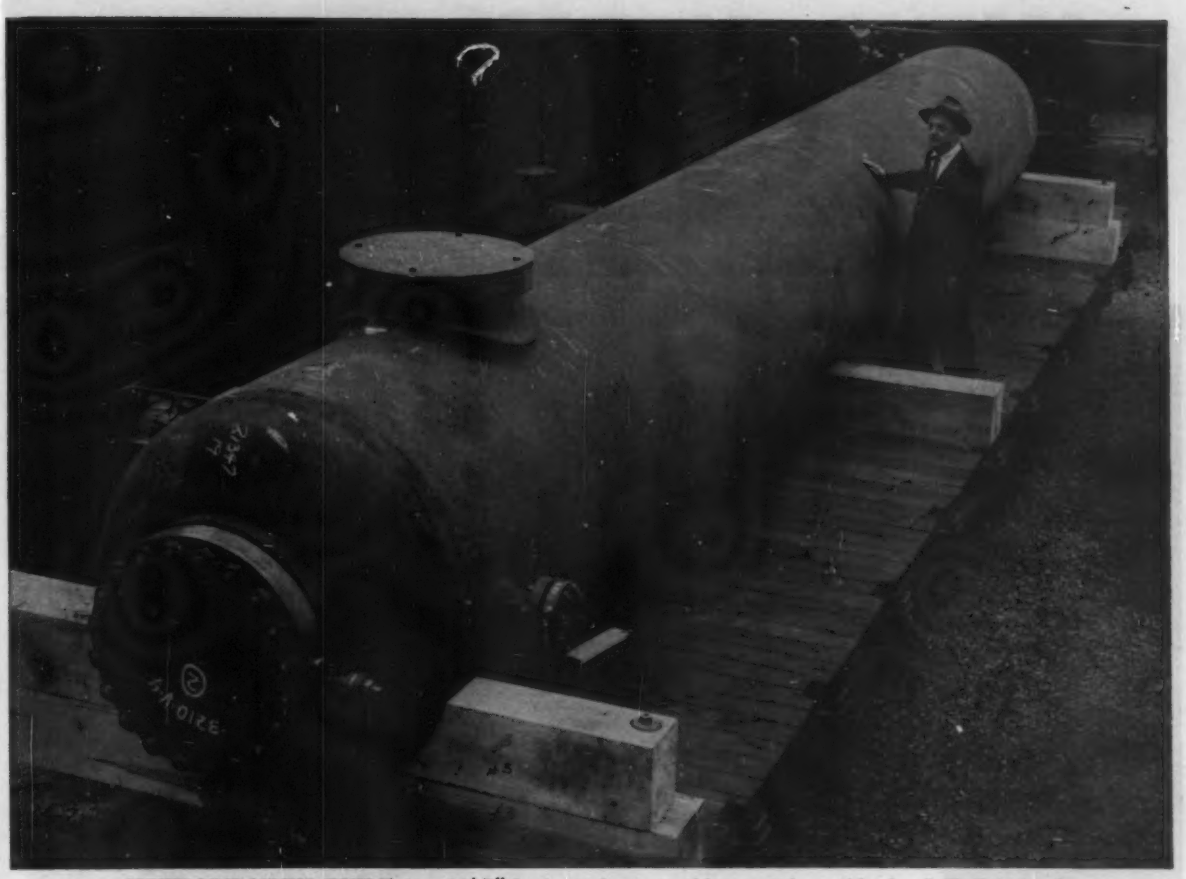
Hamlin

W. B. Marshall, Jr., professor of chemical engineering and associate dean of the University of Wisconsin College of Engineering and associate director of Wisconsin's Engineering Experiment Station, has received AIChE's 1959 Professional Progress Award. The $1,000 award

use these
READERS' SERVICE CARDS*
for more information



* see inside back cover



NEWPORT NEWS BUILT two 39'-7" horizontal gas scrubbers, such as this, for J. F. Pritchard & Co. They were made of ASTM-A212 Grade B fire box steel, with structural mesh steel interiors.

Gas scrubber made of 2⅞" steel

Newport News builds almost any type of pressure vessel and other heavy process equipment

Here is one of two horizontal gas scrubbers recently built for an operating pressure of 1800 psi at 300°F.

Newport News made both vessels from fire box steel, 2⅞ inches in thickness. We formed and automatically welded this steel into sections having a diameter of only 4 feet.

Rolling thick steel to this small diameter...no easy accomplishment, as you probably know . . . demonstrates the sort of jobs Newport News takes in stride.

Almost any type of heavy processing equipment is readily constructed by Newport News in a 225 acre plant comprising huge, fully equipped fabricating and machine shops, foundries, forge and die shops, heat treating and allied equipment as well as complete test facilities.

Newport News shop erection of fabricated units helps to speed assembly at your plant site.

Get a bid from Newport News on your present or future projects. Get the benefit of specialized production techniques. Look over the many ways in which Newport News can help you . . . write for "Facilities and Products", a very interesting booklet. It's yours for the asking.

ENGINEERS Desirable positions available at Newport News for Designers and Engineers in many categories. Address inquiries to Employment Manager.

ROLLING 2⅞" STEEL for gas scrubbers. The steel, in a hot condition, was formed on the heavy bending equipment shown here. It will cold roll mild steel up to 3 inches thick, and will hot roll any grade of steel up to a thickness of 5 inches.

Newport News Shipbuilding and Dry Dock Company
Newport News, Virginia

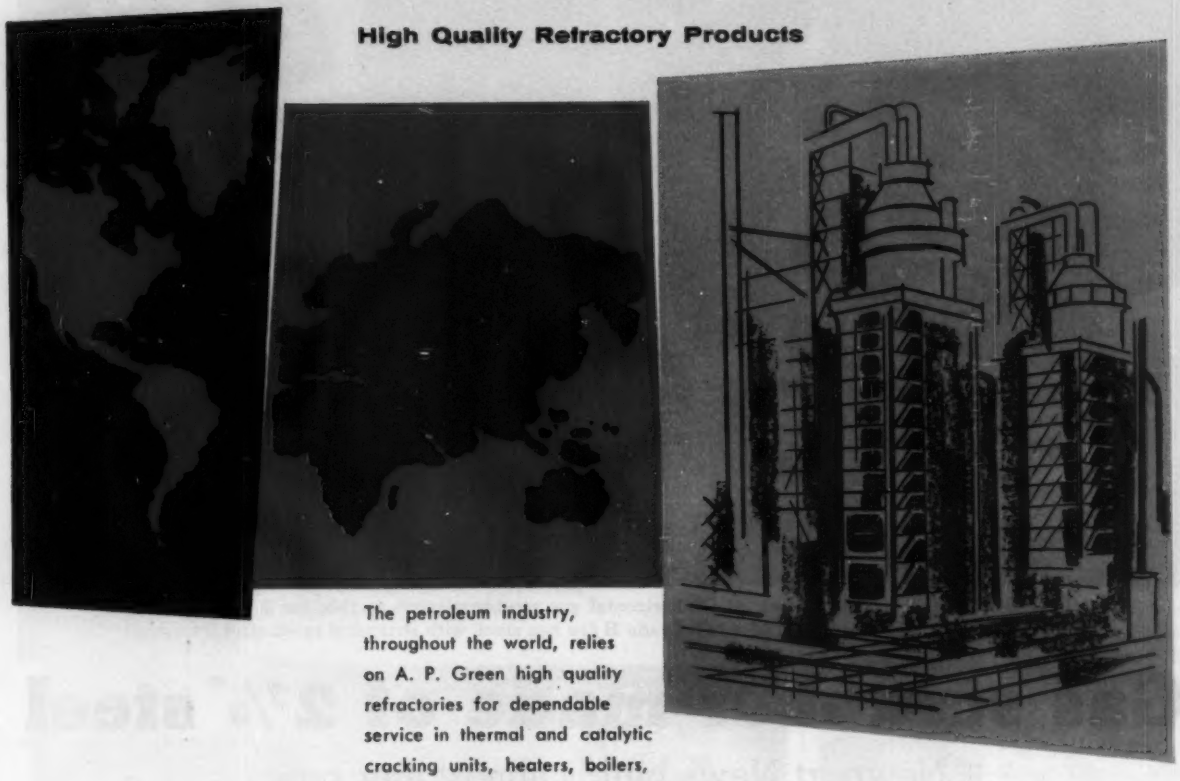
For more data on advertised products, use Readers' Service Cards, last page.

THROUGHOUT THE WORLD
A. P. GREEN

Serves the Petroleum Refining Industry

with a Complete Line of

High Quality Refractory Products



The petroleum industry, throughout the world, relies on A. P. Green high quality refractories for dependable service in thermal and catalytic cracking units, heaters, boilers, stacks, et cetera.

A world-wide network of A. P. Green distributors with engineers experienced in petroleum refining is always ready to help you select the right refractories to do the best possible job . . . at the lowest cost. For one dependable source of a complete line of refractories write . . .

A. P. Green
REFRACTORY
PRODUCTS

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

PLANTS: Mexico, Mo. • Woodbridge, N. J. • Sulphur Springs, Texas • Jackson, Oak Hill, South Webster, Ohio • Climax, Philadelphia, Pa. • Troy, Idaho • Pueblo, Colo. Macon, Ga.

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Distributors in the Principal Cities of the World

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Men . . .

and certificate, sponsored by Celanese Corp. of America, is given annually to a chemical engineer in recognition of "outstanding progress in the field of chemical engineering."

Raun

Haynes

M. David Haynes has been named assistant manufacturing manager of Tidewater Oil Co.'s Eastern Division and **E. L. Raun** has been appointed refinery superintendent at the Delaware refinery to succeed him. Haynes started with Tidewater as a development engineer in the Research and Development Department at the former Bayonne, N. J. refinery. Raun started as a process engineer at the Bayonne refinery in 1934.

E. C. Winegartner has been promoted to senior research chemical engineer in Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas. He is engaged in research on corrosion. Winegartner has a B.S. degree in metallurgical engineering from Ohio State University.

William B. Cleveland has been elected a director of Standard-Vacuum Oil Co. He became manager of Creole Petroleum Corp.'s Amuay refinery in 1956, and the following year was a director of Carter Oil Co., Tulsa. He returned to Caracas as a director of Creole in 1958, and has resigned from that company to take up his new assignment.

Ike D. Hall has been named administrative manager at Humble Oil & Refining Co.'s Baytown, Texas, refinery. He is responsible for the Coordination, Accounting, Plant Protection, Employee Relations and Medical Divisions. Hall has been with the Technical Division at Baytown since 1936. For several years he has been assistant head of that division.

Walker Lee Cisler, president of Detroit Edison Co., has been named to lead ASME. Cisler heads a slate of four vice presidents and three directors recently chosen by the Society's nominating committee. The new officers will be installed in December at the Atlantic City national meeting.

Morris Preidikman has been named assistant process engineer in Vickers Petroleum Co.'s Technical Division, Wichita. His major responsibilities will include plant modernization and expansion

NEW NEW

TYPE T The economy cable, Type T Dekoron Multicouple Cable consists of insulated, numbered and twisted wires covered with 90% closed No. 30 cotton braid and outer sheath of .050" thick 105°C PVC. Moisture and chemically resistant; approved for direct burial. Can be installed without conduit, or with smaller conduit when necessary.

TYPE A Same construction as Type T, above, except has outer covering of modified square lock galvanized steel armor overall which shields cable, serves as conduit and provides crush resistance with great flexibility.

TYPE AT Type AT Dekoron Multicouple Cables incorporate all advantages of Types A and T. Consists of armored Type A sheathed with .050" thick 105°C PVC. Moisture, chemical, and high crush resistance. Approved for direct burial or installation without conduit in open racks.

DEKORON®
MULTICOUPLE EXTENSION WIRE

Dekoron multiple pair harness of thermocouple extension wire is available *now* in three constructions, each in either Iron-Constantan or Chrome-Alumel. All are guaranteed to *meet or exceed ISA specs* for standard grade extension wire.

And — equally important — all are designed to drastically reduce thermocouple extension wire costs. Dekoron Multicouple Extension Wire reduces installation and maintenance time . . . often cuts initial material costs . . . *always lowers installed costs.*

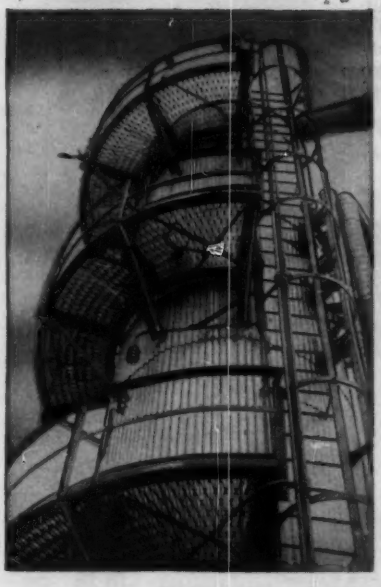
A-116A

Dekoron® products QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY
DEKORON PRODUCTS DIVISION • MANTUA, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

RAIN OR SNOW CAN MAKE CATWALKS DANGEROUS



Walkways, catwalks and treads made of solid wood, metal or other material can collect snow, rainfall, grease or oil and become dangerously slippery.

But these walking surfaces, made of an open mesh of metal bars on edge, cannot collect these substances, leaving the surface always clean, dry and tractional for safer access to high places.

As founders of the grating industry, the Irving Company can draw upon over half a century of experience to supply you with quality grating products for catwalks, treads and other practical and economical uses.

"A FITTING GRATING FOR EVERY PURPOSE"

Write for our General Grating Catalog.

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Originators of the Grating Industry

Offices and Plants at
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1890 10th St., OAKLAND 23, CALIFORNIA

Men . . .

at the firm's Potwin, Kan., refinery. Preidikman was formerly in pilot plant development work for the Gordon Lacey Chemical Product Co., New York.

Dr. Alex G. Oblad, vice president in charge of research and development, The M. W. Kellogg Co., New York, has been awarded an honorary D.S. degree by Purdue University in recognition of his accomplishments as a scientific director of research, author, and industrial executive. With Kellogg since 1957, he holds B.S. and M.S. degrees from the University of Utah and a Ph.D. degree from Purdue University. Active in many professional and honorary organizations, Dr. Oblad currently is managing editor of publications of the Division of Petroleum Chemistry, ACS, and chairman, Division Officers Group, ACS.

Oblad

W. L. Culbertson has been named manager of Phillips Petroleum Co.'s Natural Gasoline Department. He joined Phillips in Oklahoma City in 1939, just after graduation from Kansas State University. Culbertson has been assistant manager of the department since 1956.

Ole Berg, Jr., has been named executive vice president of Sunland Refining Corp., and a member of the board. He began his career with Union Oil Co. of Calif. in 1921, and eventually became vice president. In 1948 he joined British-American Oil Co., of which he became president in 1951, and was also president of the British-American Oil Producing Co., Dallas. Berg is a member of API.

Berg

Morris Preidikman has been named assistant process engineer in Vickers Petroleum Co.'s Technical Division. His major responsibilities will include plant modernization and expansion at the Potwin, Kan., refinery. Preidikman formerly did pilot plant development work for Gordon Lacey Chemical Product Co., New York.

Norman Alpert, Earl Vincent Clark and Newbold O. Cross have joined Esso Research and Engineering Co. Dr. Alpert had been associated with Texaco, Inc., as a group leader in fuels research. Clark was with Dewey & Almy Chemical Co. for four years, and Cross was with Esso Standard Oil Co., for nine years.

William W. Sellew, Jr., has been elected chairman of the board of directors, Western Petrochemical Corp. A partner in the investment firm of G. H. Walker, he is a graduate of Amherst College and Columbia University.

Ernest Fruehauf has been named a project chemical engineer at the Whiting Laboratories of Standard Oil Co. (Indiana). Before joining the firm in 1952, he received a B.S. degree in chemical engineering from the University of Wisconsin.

Dr. Alan Schriesheim has been appointed a research associate for Esso Research and Engineering Co., Linden, N. J. A member of the Process Research Division, he does exploratory research on catalysis. Before joining Esso Research in 1956, he was with the National Bureau of Standards.

J. Frank Drake has resigned as an active member of Gulf Oil Corp.'s board of directors. In recognition of his 40 years' service, the board designated him director emeritus, the first such title conferred by the company.

Robert D. Bent has been named general manager of manufacturing for The Atlantic Refining Co. Formerly assistant general manager of the department, he joined Atlantic in 1935.

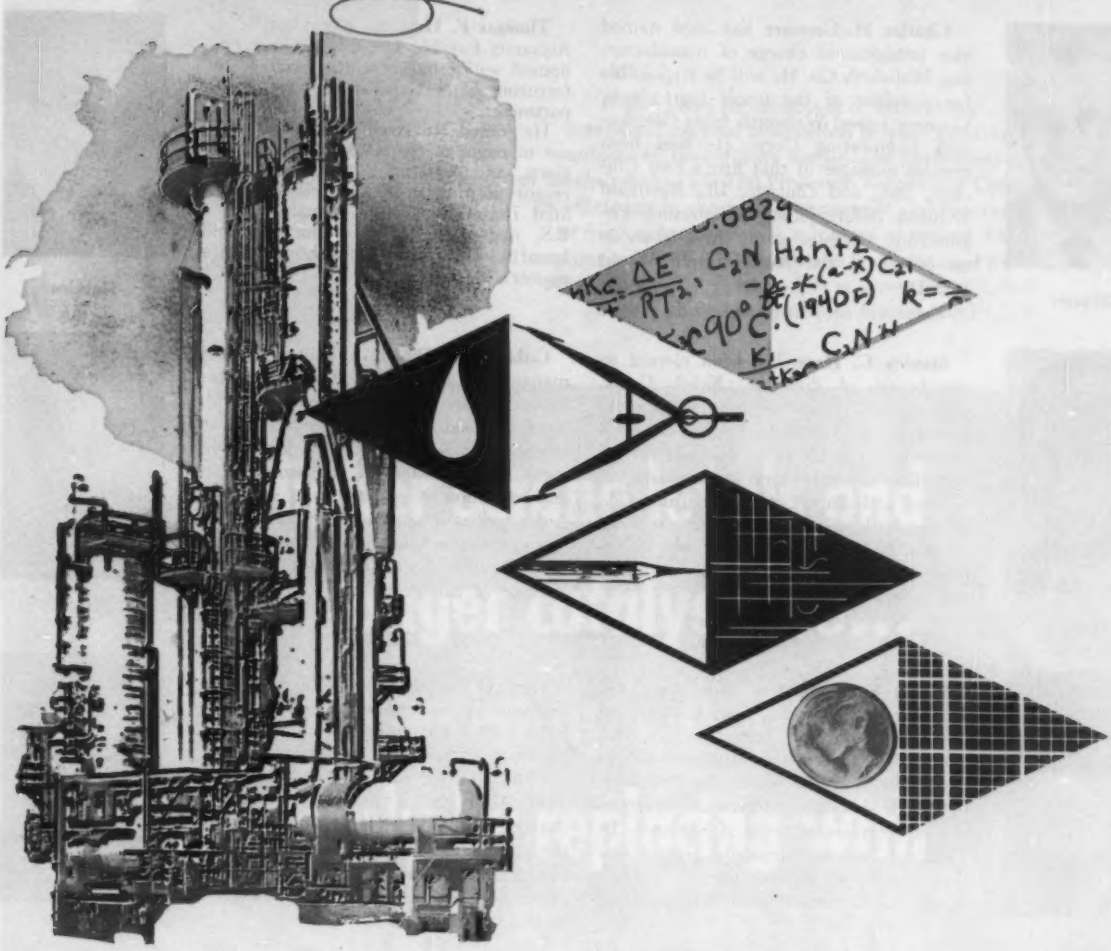
– Deaths –

Martin Frisch, vice president and director of advanced engineering, Foster Wheeler Corp., died June 16. Born in Hungary in 1899, he came to the United States in 1909, and received a mechanical engineering degree at the University of Illinois in 1921. He joined Foster Wheeler in 1929 where he was successively chief engineer, Pulverizer Division; chief engineer, Steam Division; director of engineering and development; vice president and chief engineer; general manager; Equipment Division and director of advanced engineering.

James H. Hibben, 62, a leading chemical consultant and chief of the Chemical Division, Tariff Commission, died June 15 at George Washington University Hospital, Washington, D. C. He had been a fellow of the International Education Board at Paris, a National Research Fellow at Princeton University, Consultant to the Bureau of Standards and to various chemical industries, and a member of the research staff of the Geophysical Laboratory, Carnegie Institution of Washington.

Now turn to Page 236 and read "Suppliers Notes" to keep informed about those who supply and service the industry.

intangibles were never so important



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Worker recruiting and training . . . special safety programs . . . on-the-spot solutions to pressing problems . . . these and other extras are included in Procon service. Applying such intangibles to construction of petroleum, chemical and petrochemical plants is the specialized function of Procon. Modern, efficient construction techniques form but a part of the precision construction system developed by Procon. That is why a Procon-built plant can be depended upon to more than meet specifications.

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PROCON INTERNATIONAL S. A., SANTIAGO DE CUBA

WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers Notes...

Creasser

Charles H. Creasser has been named vice president in charge of manufacturing, Walworth Co. He will be responsible for activities of the firm's four plants. Creasser joined Walworth from Combustion Engineering Corp. He had been general manager of that firm's East Chicago, Ind., and Chicago, Ill., Raymond Division. Before joining Combustion Engineering, Creasser spent three years as an officer in the Army during World War II.

Thomas F. Haskins, supervisor of the Accounts Payable Department, has been named senior buyer of Rockwell Manufacturing Co.'s General Purchasing Department.

He joined Rockwell in 1950 as assistant manager of the Rockwell Acceptance Corp. and was promoted to his most recent position in 1952. Haskins graduated from Duquesne University with a B.S. degree in business education and from the University of Pittsburgh with a master's degree.

Haskins

Hope

Stanley C. Hope has been elected to the board of directors, Nylok Corp., Paramus, N. J. He retired last year as president, Esso Standard Oil Co., with which he spent his entire business career, including several years as president of Gilbert and Barker Manufacturing Co., a Standard affiliate. Hope is president of the National Association of Manufacturers, and chairman of the Automotive Safety Foundation.

Gabriel C. Danch has been named manager, Washington Office, U. S. Industries, Inc. He was previously with Ryan Aeronautical Co. as representative in charge of all business activity in Washington. He assisted in the formulation and execution of military sales programs and negotiated contracts in the aircraft and electronics fields. Before that, he had been Ryan's executive assistant to the director of Engineering.

Danch

Ames

James K. Ames has been appointed manager of field sales, Colton Chemical Co., division of Air Reduction Co., Inc. Ames will maintain headquarters in Cleveland, and will direct the field sales force. He joined Colton as a technical service representative in Cleveland. In 1958, he became Cleveland central district manager. Before joining Colton, Ames was a chemist with Willard Storage Battery Co.

Fred O. Snyder has been appointed manager of Worthington Corp.'s District Sales Office, Cincinnati. A chemical Engineering graduate of Case Institute of Technology, he joined Worthington in 1941. After service with the U. S. Navy during World War II, he returned to the company's Cleveland Office in 1946 as an application engineer. Before his promotion he was a sales representative in the Cleveland area.

Snyder

Martin

Earl Martin has been named branch manager, Houston office, The Cooper-Bessemer Corp. He will be in direct charge of both application and sales of Cooper-Bessemer compressors and engines, and will be directly responsible for the operation of regional warehouse facilities. A graduate of the University of Kentucky, Martin was with Foxboro Co. and Rockwell Manufacturing Co. before joining Cooper-Bessemer.

John D. Weber has been elected vice president of The Swartwout Co., Cleveland, and manager of the AutroniC Control Division. He has been manager of marketing and manufacturing of the AutroniC Control Division for 18 months. Before joining Swartwout, Weber was marketing manager of the Industrial Instrument Division, Texas Instruments, Inc. He is a graduate of the U. S. Naval Academy.

Weber

Moxon

John Moxon has been elected president of The Carpenter Steel Co., Reading, Pa. Formerly executive vice president, he was associated for 14 years with Guaranty Co., New York, and the former Guaranty Trust Co., New York. With Carpenter since 1944, he is a member of the board, a position he holds with several other companies. Moxon began his career in 1915.

Harold A. Harty, advertising and sales promotion manager for Wolverine Tube Co., has been elected chairman of the board, National Industrial Advertisers Association. He was president of the Industrial Marketers of Detroit Chapter in 1947-48 and 1957-58. At the same time, he was on the board of directors, NIAA. Recently, he was chairman of the Industrial Advertising Research Institute

Harty

If you have the problem of increasing octane rating and production in your existing equipment, investigate the unique performance of Sinclair-Baker RD 150 Platinum Reforming Catalyst. Its efficiency in producing *important yield increases at high octane levels* is a matter of record. The long period of RD 150 operation is unmatched by any other catalyst . . . further, *it is regenerative in situ!* Cost is sharply reduced to lowest level.

Higher octane levels and longer catalyst life...

with existing equipment

...merely by replacing with

Sinclair-Baker RD 150 Platinum Catalyst

ENGELHARD INDUSTRIES, INC.

EXECUTIVE OFFICES:

113 ASTOR STREET · NEWARK 2, NEW JERSEY

CHEMICAL DIVISION

DOMESTIC DIVISIONS: AMERICAN PLATINUM & SILVER DIVISION, AMERSIL QUARTZ DIVISION, BAKER CONTACT DIVISION, BAKER DENTAL DIVISION, BAKER SETTING DIVISION, BAKER PLATINUM DIVISION, CHEMICAL DIVISION, EAST NEWARK INDUSTRIAL CENTER, HANOVIA LAMP DIVISION, HANOVIA LIQUID GOLD DIVISION, IRVINGTON-BAKER REFINING DIVISION, D. E. MAKEPEACE DIVISION, NATIONAL ELECTRIC INSTRUMENT DIVISION, RESEARCH AND DEVELOPMENT DIVISION, H. A. WILSON DIVISION. COMPANIES ABROAD: ENGELHARD INDUSTRIES OF CANADA, LTD. TORONTO, ENGELHARD INDUSTRIES OF QUEBEC, LTD. MONTREAL, ENGELHARD INDUSTRIES, LTD. LONDON, ENGELHARD INDUSTRIES A. G. ZURICH, ENGELHARD INDUSTRIES PTY., LTD. MELBOURNE, SOCIEDAD SURAMERICANA DE METALES PRECIOSOS S. A. BOGOTA, INDUSTRIE ENGELHARD S. P. A. ROME, ENGELHARD INDUSTRIES OF SOUTHERN AFRICA, LTD. JOHANNESBURG. ASSOCIATED COMPANIES: ACME TIMBER INDUSTRIES LTD., SOUTH AFRICAN FOREST INVESTMENTS LTD., SOUTH AFRICA, AZOPLATE CORPORATION, CHARLES ENGELHARD, INC., NUCLEAR CORP. OF AMERICA, INC., U.S.A.

For more data on advertised products, use Readers' Service Cards, last page.

OUTSELLS THEM ALL!

HERE'S WHY

1 2½ to 1 ratio – guide length to guide diameter–prevents galling and hanging up.

2 High thermal expansion rate of sleeve guide and low thermal expansion rate of hardened stem retainer eliminates binding and galling even at elevated temperatures.

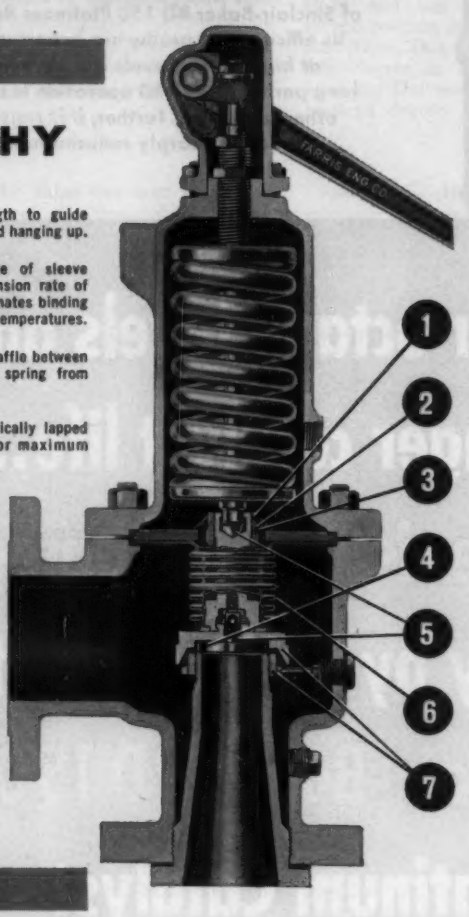
3 Sleeve guide provides solid baffle between body and bonnet, shielding spring from lading fluid.

4 Hardened stainless steel optically lapped flat disc – self aligning for maximum tightness.

5 Double universal ball joint from stem to disc for self alignment – eliminates effects of spring, temperature and piping distortion.

6 Stainless steel "BALANSEAL" bellows nullifies effect of back pressure and isolates internal working parts from lading fluid.

7 Cone-shaped disc holder directs flow away from guiding surfaces and forms fixed secondary orifice with single blowdown ring control for built-in capacity.



Farris full nozzle Safety-Relief Valves

Simplicity in design, safety in operation ... what more can you ask of a Safety-Relief Valve! The patented design features shown in this Farris valve have been *standard* for more than a decade. It's the ideal concept of a trouble-free, safe, safety valve, free from inventory and design change problems since 1945. It's the *preferred design* in full nozzle safety-relief valves for the process industry.

Detailed information for the selection and sizing of all Farris process safety-relief valves is in Catalog FE-118. Sent to you on request.

Farris ENGINEERING CORP.
536 Commercial Avenue, Palisades Park, N.J.
Texas Plant: 5405 Clinton Drive, Houston 20

affiliates: FARRIS FLEXIBLE VALVE CORP. • FARRIS PICKERING GOVERNOR CO., INC. • FARRIS ENGINEERING LTD., LONDON, ENGLAND

Suppliers ...

Projects Council. Harty has managed advertising for the Wolverine Tube and Calumet Divisions of Calumet & Hecla, Inc., since 1946.

COOPER-BESSEMER, S. A., has named **Harry A. Cecsarini** European manager. An engineering graduate of Ohio State University, Cecsarini joined Cooper-Bessemer in 1949. He will headquarter at company offices, The Hague, Netherlands.

METAL SERVICES, INC., Beaumont, Texas, has appointed **Cooper F. Hawthorne** vice president and general manager. Formerly vice president and general manager of Nowery J. Smith Co., Houston, he studied petroleum and chemical engineering at The University of Texas. Hawthorne was in the Air Force as a reserve officer from 1941-46, and as a regular officer from 1947-54. He is a member of NACE and the Affairs Committee, American Hot-Dip Galvanizing Association.

Hawthorne

GENERAL AMERICAN TRANSPORTATION CORP.'s Paul Talmey, director of research and development, has been elected to the board of directors. He began his career in 1930 after graduating from Yale University, where he majored in physics, mathematics and chemistry. Since 1954 he has been a director of Fuller Co., a General American subsidiary.

KEASBEY & MATTISON CO., Ambler, Pa., has named **S. R. MacWhinney** merchandising manager of asbestos-cement pressure pipe. Asbestos-Cement Pipe Division. He joined K&M in 1956 as a general line salesman, Chicago district, MacWhinney was formerly with Paige & Hill Homes, Inc., as a sales project engineer.

TRUCK & TRACTOR EQUIPMENT, LTD., Dixie (Toronto), Ont., has been appointed a distributor for Bucyrus-Erie Co., and Bucyrus-Erie Co. of Canada, Ltd. Territory covered includes Southern and Northeastern Ontario.

COOPER-BESSEMER INTERNATIONAL CORP. has named **Leopold A. Ffrench** sales representative. A graduate of Rice Institute, he holds a chemical engineering degree. Ffrench was formerly with Clark Bros. Co. as a sales engineer.

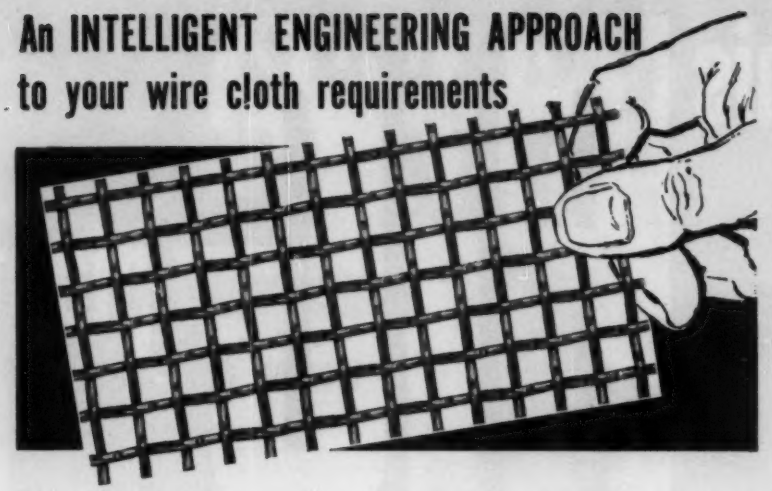
THE CARPENTER STEEL CO's. Alloy Tube Division, Union, N. J., has named **Paul E. Kelly** manager of sales, **Selden E. Doughty,** manager of technical services, and **Griffin M. Stabler** manager of production. Kelly, formerly assistant manager of sales, joined Carpenter as a salesman in 1945. Doughty, previously production manager at the Union plant, joined the firm in 1946 as a metallurgist,

Swagelok® engineers believe that NO fitting is too good if it keeps your plant in operation

A tube fitting is small in size but large in importance when you consider that the most minute leak in a system can cause the shutdown of a multi-million dollar plant. Swagelok Tube Fittings represent more than a mechanical necessity. **They are an investment in security**... the type of solid security which results from the use of the finest fittings assuring constant trouble-free, leak-proof operation.

Crawford Fitting Company • 884 East 140th St. • Cleveland 10, Ohio
Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

An INTELLIGENT ENGINEERING APPROACH to your wire cloth requirements



An intelligent engineering approach to wire cloth and screen requirements pays dividends. Cleveland Wire Cloth, knowing alloy, tolerances, openings, crimping and tightness of weave, study the materials being processed, processing conditions and the end results before specifying any wire cloth. They may select from hundreds of unsurpassed quality cloth in stock, or if necessary, will weave a screen for your needs. Contact Cleveland today for an intelligent engineering approach to your wire cloth and fabricated screen problems. Ask for Bulletin No. 10.

SEE OUR AD IN REFINERY CATALOG

THE CLEVELAND WIRE CLOTH & MFG. CO.
3671 EAST 78th STREET, CLEVELAND 6, OHIO • DI 1-1832

"PYROMETEERS"
PYROMETER ENGINEERS, BUYERS, EXECUTIVES
attending the CHICAGO **ISA** Show
we invite you to our **BIG PARTY**

PALMER HOUSE HOTEL

INDUSTRIAL PYROMETER AND SUPPLY Co ALTON ILL U.S.A.

GRAND BALLROOM

★ 2 NIGHTS . . .
Tues., Sept. 22 and Thurs., Sept. 24
★ See our Gigantic Floor Show
★ Big Bar—The finest liquors
★ 15 Piece Orchestra—Dancing
★ Big Buffet Supper
★ Beautiful Girls—Side Attractions.

9:00 P. M. TILL 2:00 A.M.

See Our Booth . . . Number 252 Chicago International Amphitheater
Write for invitation

World's largest manufacturer of Pyrometer and Thermocouple Extension Lead Wire

INDUSTRIAL PYROMETER AND SUPPLY COMPANY
ALTON, ILLINOIS, U.S.A.

Suppliers . . .

was named chief metallurgist in 1953, and became production manager in May 1954.

Stabler, formerly plant superintendent, succeeds Doughty as manager of production. He joined Carpenter in 1951 as assistant purchasing agent, and in 1953 formed the Tube Division's Industrial Engineering Department. He became plant superintendent in 1957.

CHEMETRON CORP.'s Chemical Products Division has established a Chicago field office for Girdler Catalysts, Louisville, Ky. **Richard J. Ambrosen,** a development engineer with Chemetron since late 1955, heads the new office, which will handle sales and provide technical services to users of Girdler catalysts in the Midwest. The address is at 840 N. Michigan Ave.

H. K. PORTER CO., INC., has sold the land and three factories of the Laclede Works of its Refractories Division, St. Louis, Mo., to interests in the name of **Ann S. Dattilo.** Porter has been operating only one of the factories, and will continue to operate it with no change in present employment, under a five-year lease agreement.

ALLIED CHEMICAL CORP.'s Solvay Process Division has named **Herbert Kishbaugh** manager, New York Sales Branch. A graduate of the University of Tennessee, he joined Solvay's Advertising Department in 1948.

WORTHINGTON CORP.'s Victor Salemann, research engineer, Harrison Division, has been awarded the ASME Mechanical Engineers' 1959 Junior Award. The award is presented annually for the best technical paper published during the year by an associate member of ASME.

THE OKONITE CORP.'s Sam R. Howard has been named district manager, Los Angeles District sales office. He has been with the office as a sales engineer since 1956.

CHIKSAN CO. has purchased the business and properties of Hamer Valves, Inc., Long Beach, Cal. The purchase price has not been disclosed.

AMERICAN CYANAMID CO.'s Process Chemicals Department has named **Charles H. Groezinger, Jr.,** assistant to the manager. He joined Cyanamid in 1950 as a technical sales and service representative, Industrial Chemicals Division, and has since held several posts with the division's Refinery Chemicals Department.

THE TERRY STEAM TURBINE CO. has named **A. Lindsay Thomson** president and treasurer. With Terry since 1939, he was elected secretary in 1950, vice president in 1956, and a director in 1957.

BECKMAN INSTRUMENTS, INC.'s Scientific and Process Instruments Division has named **David C. Nelson** field sales engineer, scientific instruments, Seattle office. A graduate of the University of Red-

Stainless Steel pipes cool hot acid

AT SINCLAIR REFINING COMPANY, HOUSTON, TEXAS

This continuous SO_3 sulfonization unit produces a high detergent lube oil additive. The picture shows Type 316 Stainless Steel pipes in the cooler. 98% sulfuric acid enters the coils at about 145°F and is cooled to 105°F by water.

The pipes take punishment three ways: high temperature, acid corrosion, and erosion. At first, some of the pipes were made of a less resistant metal but they had to be replaced with Stainless Steel after only eight months. There has not been one sign of deterioration in the replacements or in the Stainless Steel pipes installed originally.

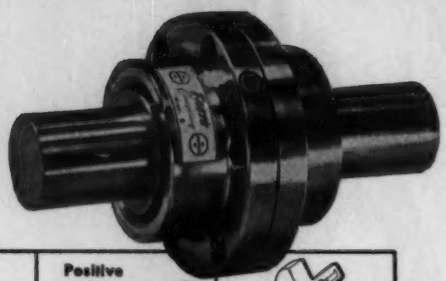
When you install equipment, design it with the right material from the start. If you need strength and corrosion resistance, there is no metal that can match the performance and economy of Stainless Steel. Order USS Stainless Steel through your U. S. Steel representative or your local Steel Service Center.

USS is a registered trademark

United States Steel Corporation – Pittsburgh
American Steel & Wire – Cleveland
National Tube – Pittsburgh
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Supply – Steel Service Centers
United States Steel Export Company

USS United States Steel

FAST'S Model B Coupling



reduces downtime and upkeep for light-to-medium drives!

Now you can profit from the durability and economy of famous Fast's couplings in a smaller and lower-cost version—available in 5 sizes for shafts ½" to 3⅛" in diameter.

The Model B coupling gives you the same features that have made Fast's the world's leading coupling for over 35 years. You get the same trouble-free performance, longer service life and lower maintenance costs. You also get prompt delivery because stocks are on hand to meet practically every need. Free engineering service is also available.

Write today for more details to KOPPERS COMPANY, INC., Fast's Coupling Dept., 6108 Scott Street, Baltimore 3, Maryland.

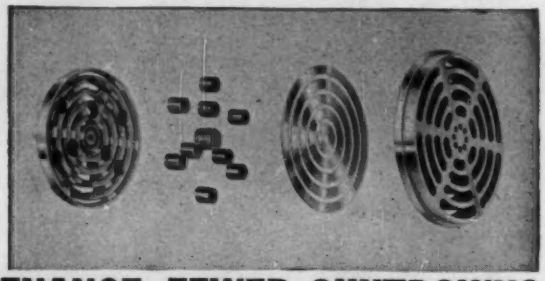
Engineered Products Sold with *Service*

KOPPERS

THE ORIGINAL *FAST'S Couplings*

VOSS VALVES

in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast)—using best alloy steels; for corrosion condition—stainless steels, such as 410, 18-8 or non-ferrous alloys—monel, inconel, etc. PLATES are machined (not stamped) and ground for precise close tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J. H. VOSS VALVES REG U.S. PAT. OFF.

J. H. H. VOSS Co., Inc.
785 East 144th Street, New York 54, N. Y.

Suppliers . . .

lands, Nelson recived his B.S. degree in chemistry in 1954 and his M.S. degree in analytical chemistry from the University of Minnesota in 1956.

THE BENDIX COMPUTER DIVISION'S district sales office for the San Francisco Bay area and Northwest has moved to 1330 Broadway, Suite 1121, Oakland.

THE OKONITE CO.'s Tulsa office has named **Douglas J. O'Connor** branch manager. An engineering graduate of the U. S. Military Academy, he was previously at the Atlanta office as a sales engineer.

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS CO. has named **Rigdon Currie** Southwestern regional sales manager. He will establish offices in Houston later this year and will be responsible for all sales activities in the Southwest.

COMPUTER SYSTEMS, INC., has appointed **Thaddeus J. Kusto** director of research. Before joining Computer Systems he was executive vice president of E.P.R. Special Products Corp.

WALWORTH CO. has named **Joseph G. Younggren** assistant division manager, Gulf Division. With Walworth 17 years, he had been in New Orleans.

CRANE CO. has named **Joseph A. Donahue** manager of sales promotion. He previously operated the consulting firm of Donahue and Associates, La Salle, Ill.

AMERICAN MARC, INC., has acquired Creger Marine, boat manufacturer, Seal Beach, Calif., which becomes a division of American Marc.

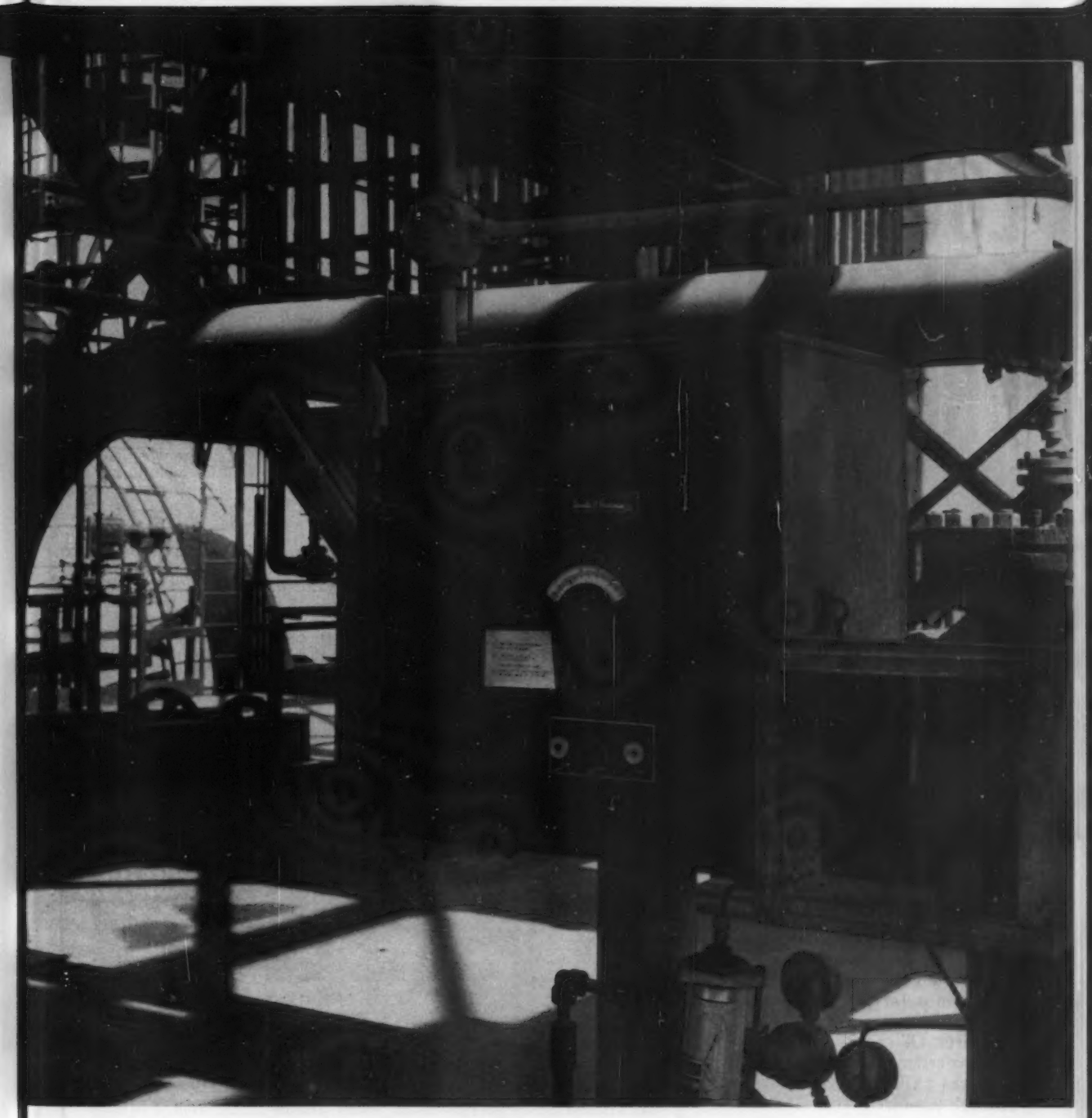
THE A. P. GREEN FIRE BRICK CO. has named **Hugh Lowry** sales representative, Memphis territory. With the company 13 years, he previously was a representative for Illinois A. P. Green Fire Brick, Chicago.

AMERICAN MARC, INC., has appointed Allied Diesel Sales and Service, Inc., Boston, exclusive distributor for Massachusetts, Rhode Island, New Hampshire and Connecticut. The distributorship maintains complete diesel sales, service and parts facilities.

A. O. SMITH CORP.'s Process Equipment Division, Milwaukee, has almost completed a $2-million expansion adding 80,000 additional square feet of floor space and major heavy equipment, primarily for the manufacture of pressure vessels.

ALUMINUM CO. OF AMERICA plans to install a 5,200-ton capacity extrusion press, part of a multi-million-dollar expansion program, at its Vernon, Calif., works. It will go into production early in 1960.

W. R. GRACE & CO. and Hatco Chemical Co. have reached an agreement under which Grace would acquire the business and assets of Hatco in exchange for 126,000 shares of Grace common stock,



The sentinel that never gets relief... Day after day after day, for over 4 years this Beckman oxygen analyzer has maintained vigil on catalyst regeneration. Located eight stories above The Texas Company refinery at Wilmington, California, it has monitored unreacted oxygen, under demanding conditions, with only minimum routine maintenance. Analysis must be continuous, dependable, accurate. ⌘ This Beckman instrument is the only oxygen analyzer to use a direct paramagnetic measurement exclusively, which brings you these advantages: *Dependability*... under the most rugged conditions. *Simplicity*...with no auxiliary measurements to complicate analysis, no extra components requiring extra maintenance. *Accuracy*...with sensitivity and specificity to meet the most critical process requirements. ⌘ Whatever your application, if you want detailed specifications on an oxygen analyzer that withstands tough environments and gives you continuous, dependable answers, write for Data File 3P-6-25.

Beckman
Scientific and Process Instruments Division
Beckman Instruments, Inc.
2500 Fullerton Road, Fullerton, California

It's a Fact: A Beckman Infrared Analyzer has successfully controlled heat input to a refining tower for three years, maximizing ethylene recovery and minimizing methane content by analysis of the bottoms of a demethanizing absorber.

A Vital Feature...

LOWER PRESSURE DROPS

with

ARLCITE

CATALYST BED SUPPORTS

Super-strong ARLCITE Spheres insure minimum pressure drops in product flow through catalyst bed supports. Of special high-density alumina-ceramic composition, Arlcite Spheres have high compressive strength combined with extreme resistance to thermal shock.

Repeated temperature cycling, years of service will not cause Arlcite to crumble, split or chip. The interstices between the balls thus remain free of fines to maintain a constant low pressure drop. Investigate the economy of ARLCITE Spheres in *your* catalytic refining process. Write!

PORCELAIN DIVISION
FERRO CORPORATION
East Liverpool, Ohio

Suppliers...

plus possible additional shares depending on the future Hatco earnings. Hatco produces esters and synthetic lubricants for jet engines in a plant at Fords, N. J.

CLARK BROS. CO. has named **Z. B. Deer, Jr.,** sales engineer, Texas-Oklahoma Panhandle area. He will be responsible for the sales throughout Northern New Mexico, the Oklahoma and Texas Panhandles, and the Liberal Kansas Area. He was formerly Chemical Division supervisor, Celenese Corp.

CHEMETRON CORP.'s Chemical Products Division has named **Duane W. Allen** technical service director, Girdler Catalysts, Louisville, Ky. He was a supervisor of production research for Brown & Williamson Tobacco Co., Louisville, before joining Girdler.

FRITZ W. GLITSCH & SONS., INC., has named **William C. Diller** district sales manager, Charleston, W. Va. He has a B.S. degree in chemistry from Ohio University, and for the past nine years has been in the chemical process industry, Charleston area.

NALCO CHEMICAL CO. has named **Dr. David G. Braithwaite** head of commercial development. A director and former head of Nalco's Catalyst Division, he will guide a number of the company's expansion and development activities.

DRESSER INDUSTRIES, INC.'s Dresser Manufacturing Division has named **Theodore A. Short** sales promotion manager for original equipment, Bradford, Pa. He was formerly with Goodyear Tire & Rubber Co.

WARREN PUMPS, INC., has appointed Howell Engineering Equipment Co. industrial sales representative in the St. Louis area. The firm is at 4229 Lindell Boulevard, St. Louis.

BORG-WARNER CORP.'s Spring Division has named **S. J. Becker** vice president and chief engineer. He has been with the division since 1940.

CONSOLIDATED ELECTRODYNAMICS CORP.'s Transducer Division has named **Howard B. Lewis** chief engineer. He joined the firm in 1952 as a development engineer, became a supervisory development engineer in 1957 and a senior supervisory development engineer in March, 1959.

MINNEAPOLIS-HONEYWELL REGULATOR CO. appointed to its Mid-Atlantic Region **Edward J. Klein,** regional industrial manager, Philadelphia; **John J. Horner,** industrial manager, Philadelphia branch office, and **Carl F. Boehnlein,** industrial manager, Richmond, Va., branch office. The men are all long-time Honeywell employes.

BENDIX AVIATION CORP. has named **Tullio Tognola,** assistant director of engineering, Scintilla Division, Sidney, N. Y. With Bendix since 1929, he became chief research engineer in 1939.

MOST MAJOR U.S. PETROLEUM REFINERS REDUCE COSTS with PANALARM ANNUNCIATORS

MAXIMUM INFORMATION on all process variables . . . the result of 10 years system engineering by Panalarm and major petroleum refiners. That's why Universal Series 50 is the petroleum industry's most informative annunciator. Trouble anywhere is signalled instantly—*before* it can grow big and expensive. "Off-normals" are pinpointed instantly, accurately for fast remedial action, reducing costly downtime.

Economical, highly flexible design facilitates system expansion. Can be simply adapted to your exact requirement, avoiding costly custom designing. Proven components—e.g., almost 1,000,000 dependable Panalarm developed relays have been used in Panalarm Annunciators.

Ask your nearby Panalarm sales engineer to show you why Universal Series 50 is the petroleum industry's No. 1 annunciator choice . . . how its adaptability and reliability can help increase your profits . . . by producing maximum information and reducing costly downtime. No obligation, of course.

Write for Catalog 100 B today.

PANALARM®

Division of
PANELLIT, INC.
7401 No. Hamlin Ave., Skokie, Ill.

For more data on advertised products, use Readers' Service Cards, last page.

This electronic Speedomax instrument, calibrated in % ethane plus methane in ethylene, is panel-mounted in the Port Arthur control room to serve as recording teammate to the L&N Analyzer.

Infrared analysis helps Gulf to pipe "on spec" ethylene directly to consumers, without tankage or sampling

There's no costly storage—no laborious sampling or blending before shipment of the high-purity ethylene produced at Gulf Oil's Port Arthur Refinery. Operators are *certain* that the plant stream is always "on spec", as it runs from production directly to pipelines serving the ethylene-hungry industries of the Houston—Sabine River—Port Neches area.

One reason for such confidence in product quality is the L&N Infrared Analyzer that Gulf has installed to constantly monitor impurities in the ethylene stream. Should the sensitive Analyzer detect a predetermined percentage of impurity, operators can promptly divert "off spec" stream before "on spec" product in the lines can be contaminated.

Even though subjected constantly to the vibrations of a pipeline mounting, and electrical pick-up from pumps and compressors, the Analyzer checks consistently with daily spectrometer analyses—a tribute to the L&N instrument's all 'round dependability.

The Analyzer's prominent role at Port Arthur is duplicated in many other successful applications of this versatile instrument. It's measuring CO and CO_2 in the steel industry—SO_2 in H_2SO_4 stack gas—methane build-up in ammonia production—isobutane loss in petroleum. It may well be the yardstick *you* need in your own gas measurements.

Our Applications Lab is staffed with specialists glad to discuss your use of infrared. Outline your requirements, without obligation, in the Infrared Analysis Data Sheet we'll mail on request. Or, just write for our Demonstrator, "How the L&N Infrared Gas Analyzer Works." The address is Leeds & Northrup Co., 4923 Stenton Ave., Phila. 44, Pa.

LEEDS NORTHRUP
Instruments *automatic controls • furnaces*

For more data on advertised products, use Readers' Service Cards, last page.

REPAIR PIPE LEAKS
QUICKLY
PERMANENTLY
ANY PRESSURE
ANY TEMPERATURE

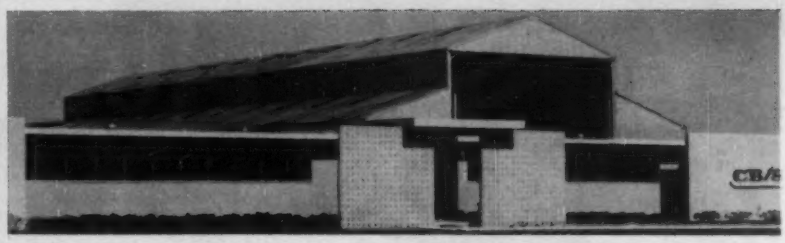
SKINNER-SEAL
EMERGENCY PIPE CLAMPS for safe, sure lasting repair of splits and rust holes in pipe. No pressure too high. Anyone can apply in a few moments. Made in all sizes, ½" to 12", for steel and C. I. pipe. Stocked by practically all oil supply stores.

SKINNER-SEAL
COLLAR LEAK CLAMPS—for oil and gas lines. Gasket is sealed by gasket container rings—pressure is sealed in . . . air, moisture and gasket-destroying soil conditions are sealed out. Effective under any pressure. Sizes 2"—13" O.D. incl. In stock at oil supply stores!

For over half a century, a complete line of Repair Clamps and Saddles for steel and cast iron pipe. Send for catalog!

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

Suppliers . . .



C-B Southern, Inc., has opened this new $600,000 plant in Houston to manufacture packaged gas compressors. Employing about 100 people, the installation will have a capacity of 120 packaged compressors annually.

HENRY J. KAISER CO.'s George Havas, general manager, Heavy Construction Division, has received the honorary degree of doctor of engineering from Rensselaer Polytechnic Institute of Troy, New York "in recognition of his outstanding record as one of the world's foremost builders."

HEYDEN NEWPORT CHEMICAL CORP. has named **David X. Klein** technical director, Heyden Chemical Division. Formerly manager of research at the company's Garfield, N. J. laboratories, he will be responsible for division expansion and new products programs.

AMERICAN PLASTICS CORP. has named, as new vice presidents, **John A. Parsons, J. William Arpin,** and **Elmer G. Smith,** all of Bainbridge, N. Y. Parsons, named executive vice president, had been director and vice president in charge of production.

BLACK, SIVALLS & BRYSON, INC., has named **Charles H. Myers** vice president of Industrial Relations. He has been a vice president and member of the board of directors since 1946.

AMERICAN CYANAMID CO. has named **R. E. Leach** manager of its Marietta, Ohio, plant, and **A. C. Fennimore** manager of the Willow Island, W. Va., plant. **J. W. Dykes,** who has managed both locations for more than 10 years, has been named manufacturing management consultant to the Organic Chemicals Division.

CONSOLIDATED ELECTRODYNAMICS CORP. has named **Donald E. Stocking** Eastern Regional manager with headquarters in Philadelphia. With CEC since 1954, he was previously an engineer with Eastman Kodak Co.

PHILIP CAREY MFG. CO. has named **Frank W. Lippard** assistant manager, Quality Control Division, Cincinnati. He will assist in quality control and inspection operations of Carey's Lockland; Perth Amboy, N. J.; Houston; Memphis and Wilmington, Ill. plants. Lippard was previously manager of engineering.

DE LAVAL STEAM TURBINE CO. has named **Paul S. Nurko** works manager, Trenton, N. J. He was previously general superintendent of the Manufacturing Division.

New officers of the Natural Gasoline Supply Men's Association taking office at a recent board meeting in Dallas are: (seated, l to r) President R. P. Walker, Minneapolis-Honeywell Regulator Co., Oklahoma City; retiring President H. O. Sears, Alliger & Sears Co., Houston; Vice President Ray Riddle, Riddle & Hubbell Co., Tulsa. (Standing, l to r) Secretary W. F. Lowe, Tulsa; Vice President E. O. Haltom, Trinity Steel Co., Dallas, and Treasurer C. P. Stanley, Dresser Engineering Co., Tulsa.

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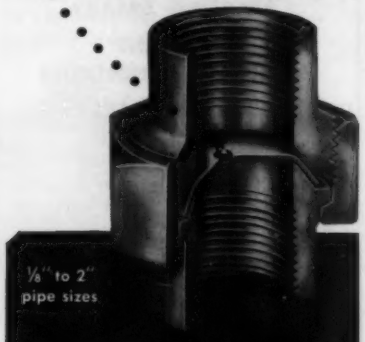

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"The Drinking Problems and its Control" deals with the problem of alcoholism—probably one of industry's biggest headaches. One of 50 industry employes is an alcoholic. The alcoholic has twice as many accidents as the non-alcoholic. He costs industry 36-million working days a year, and our national economy more than $1-billion annually.

Recognizing the need for a concise and authoritative book on alcoholism, Gulf Publishing Co., has published this authoritative book, written by the assistant medical director for E. I. du Pont de Nemours & Co. It covers important questions such as: What is alcoholism? What are the fears of the alcoholic? Is there a typical description of an alcoholic? What is industry's role? What is the treatment? What is the cure? The book deals not only with alcoholism generally, but also discusses its effects, and care and treatment when encountered on the job.

(Dr. C. A. D'Alonzo, M.D., *The Drinking Problem and Its Control,* Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, 130 pages, $2.95.)

How to Invent

"How to Invent" shows that with proper training the creativity of this country's scientists and technologists can be increased at least eight times. This book provides the reader with a guide to mental techniques of learning to invent . . . and their application to daily thinking. According to the author: ". . . just because you have never invented anything does not mean you have no talent for it." He points out that there is no easy or magical way to become an inventor.

In addition to the interesting coverage of best ways to prepare for invention, the book provides the reader with a detailed discussion of patent practices he should know such as: how to decide what is patentable, how to go about obtaining a patent, what a patent really means and how to protect a patent from the beginning.

(Gilmore, Forrest E., *How to Invent,* Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, 89 pages, $2.50.)

Fringe Benefits

"Fringe Benefits" covers the history, cost, and economic significance of known fringe benefits. Benefits included are both compulsory and voluntary—vacations, pensions, retirement plans, insurance, shift bonus, paid sick leaves, jury duty pay, family death, guaranteed annual wage, supplemental unemployment benefits, and many others. The book also outlines cost analysis for benefit programs, and evaluates fringe benefits in terms of employe attitude.

(Wistert, F. M., *Fringe Benefits,* Reinhold Publishing Co., 430 Park Ave., New York 22, N.Y., 155 pages, $3.75.)

Piping Man-Hour Manual

"Estimator's Piping Man Hour Manual" shows that production percentages can be classified into five categories: very low, low, average, very good and excellent. Production elements can be grouped into six different listings or categories: general economy, project supervision, labor relations, job conditions, equipment and weather.

The authors have devised an accurate and convenient method of estimating direct labor for complete fabrication and installation of process piping for any system. Thus, with the manual, the reader can obtain a production efficiency percentage by applying all known local conditions and variables. He can also obtain a complete direct labor rate for the craft or crafts involved in the various operations.

Subject areas covered include: shop fabrication of pipe and fittings, field fabrication and erection, alloy and nonferrous fabrication, underground piping, hangers and supports, painting, patent scaffolding, and insulation. To help the reader get more from the manual, the authors have provided a comprehensive sample estimate. Also, there is a section devoted to technical information which will be of benefit to the reader in preparing an estimate.

Page, J. S., and Nation, J. G., *Estimator's Piping Man Hour Manual,* Gulf Publishing Co., P.O. Box 2608, Houston 1, Texas, $7.50.)

NBS Standard Materials

"Standard Materials Issued by the National Bureau of Standards" (Circular 552, Third Edition) lists the standard materials issued by the Bureau and their prices. Some principal uses of NBS standard materials are (1) checking analytical methods, (2) standardizing solutions for volumetric analysis, (3) developing new or improved methods of analysis and, (4) calibrating and standardizing spectrometers, spectrographs, colorimeters, pH meters, geiger counters, scintillators, ionization chambers, pyrometers, polarimeters, refractometers, viscometers.

(NBS, *Standard Materials Issued by the National Bureau of Standards, Circular 552, Third Edition,* Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C., 27 pages, $.35.)

Scientific Manpower

"The Management of Scientific Manpower" is an AMA management report in which research and engineering administrators for many of the nation's large corporations show how they recruit, hire, and evaluate personnel. The structure and functions of research and engineering organization in the chemical industry is discussed, along with ways of planning

Expansion Joint Design Moves out of the "Model T" Era

Badger first began fabricating packless metal bellows expansion joints more than 35 years ago. These "Model T" joints performed (and are still performing) with outstanding success in hundreds of process and steam line piping installations.

Starting in the 30's other expansion joint manufacturers entered the field. The most successful adopted many of the basic features of the original Badger design.

During the last decade, as industry's requirements became more stringent, and joint manufacturers gained fabricating and field experience, certain fundamental problems inherent in the early designs became evident. Most of these problems were solved through a series of modifications. (Among which was the Badger Directed Flexing Self-Equalizing Joint — the famous "DFSE" Design.) But, at best, the modifications were stop-gap measures which complicated the joints and greatly increased their weight. A fundamental reassessment of expansion joint engineering data was needed. Badger led the way: In 1956, a task force completed a three-year research program and the first S-R (Service-Rated) Expansion Joints were produced.

In the three years they have been available, S-R Expansion Joints have been both an engineering and a sales success. But like many revolutionary concepts which upset tradition, the full implication of the advantages S-R Joints offer is still not universally understood. The message that follows is an attempt "to set the record straight."

• • • • •

Equalization — fact and fiction

Many users of expansion joints are under the impression that the so-called "equalizing" rings on today's conventional type expansion joints distribute movement equally among all the corrugations of the bellows. It is argued that as the joint absorbs thermal movement, the tops of the rings progressively come into contact until the bellows is fully compressed thus limiting the amount of compression which any one corrugation can ultimately absorb (see diagram 1). In *this* sense the rings do contribute to the "equalization" of movement by physically limiting the compression of each corrugation to the distance between any two adjacent rings.

Diagram 1

Conventional Type Expansion Joint. Cross-sections of rings and bellows of a conventional "self-equalizing" joint showing cold and hot positions. Note that true equalization of movement can only be obtained when tops of all rings are in contact — an impractical and dangerous situation.

Note, however, that the degree of compression will not be truly equalized until the tops of all the rings are in contact. But, when such a condition occurs, serious problems will result. If the limit of compressibility is reached before the thermal expansion has been completely absorbed, exceedingly large forces will be transmitted through the pipe line to the anchors and connected equipment. On the other hand, if the joint is compressed only partially, not all of the corrugations will absorb movement to the same degree.

How S-R Joints solve equalization problem

Badger S-R Expansion Joints feature the new Curvilinear Corrugations which naturally assume an "all curve" shape under pressure (diagram 2), assuring more equal distribution of stresses throughout the bellows material. Furthermore, the shape, height and pitch of the corrugations are based on a carefully engineered correlation. Thus, reasonably equal distribution of movement among the corrugations is obtained, even in joints not equipped with reinforcing rings.

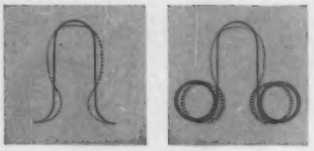

Diagram 2

Badger S-R Expansion Joint. Cross-sections of S-R Joints (Series 50 left, Series 150 right). The movement of the corrugations is shown by dotted and solid lines. Compare configuration and effective height of corrugations, position and size of rings with conventional joint.

Equalization of movement is inherent in the design and functioning of the bellows on Badger S-R Joints. On the basis of provable engineering criteria, the prime purpose of reinforcing rings of any design is to retain the hoop dimension (diameter) of the corrugations when they are subject to internal pressure. This Badger's simple, lightweight tubular reinforcing rings do. But, in addition, the new tubular shape of the rings does contribute to joint flexibility and life by permitting flexing over a more effective portion of the total corrugation height than conventional cast or fabricated equalizing rings.

Better performance, lower cost

Briefly, then, Badger S-R Joints alone offer these advantages: Better equalization of movement which results in elimination of localized stresses and leads to longer joint life; a simple, lightweight design that makes installation easier, eliminates cumbersome castings and fragile mechanical devices; complete range of sizes from 3″ to 72″ made from any workable metal and with a wide choice of accessories.

Badger S-R Joints are probably the answer to your problem. There's an easy and quick way to find out — ask the Badgerman for his recommendations. Write or phone today. Badger Manufacturing Co., 230 Bent St., Cambridge, Mass.

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BADGER S·R EXPANSION JOINTS

For more data on advertised products, use Readers' Service Cards, last page.

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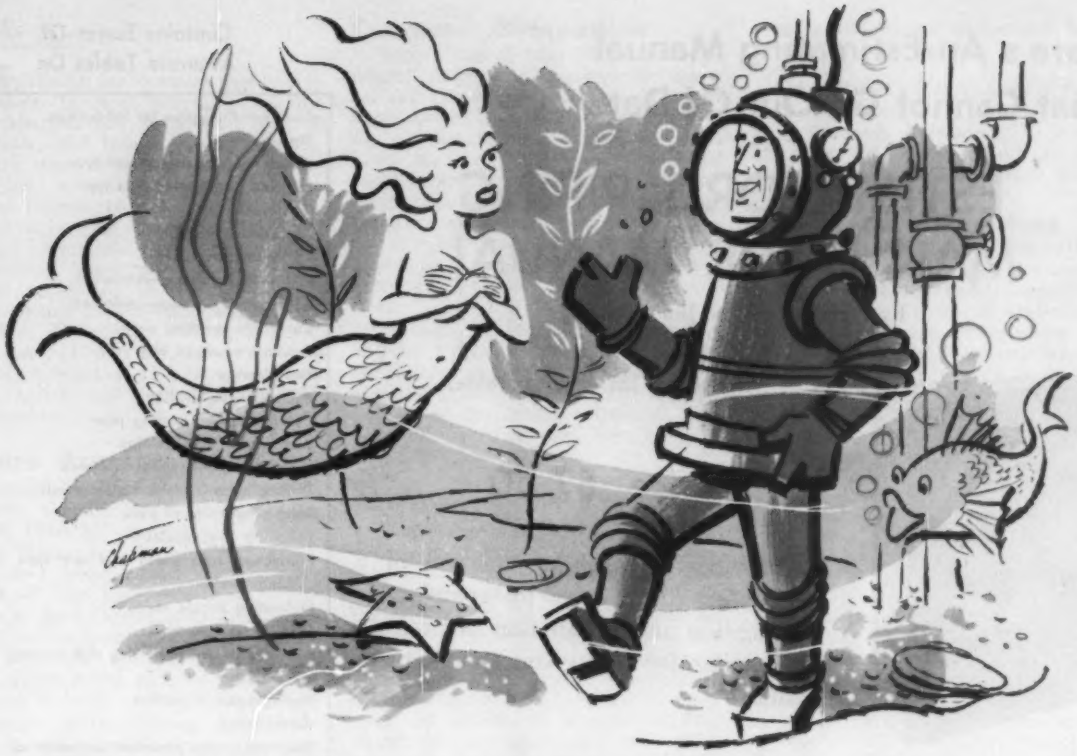

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Using the above experience, the authors have devised an accurate and convenient method of estimating direct labor for complete fabrication and installation of process piping for any given system. Thus, by means of this manual, the reader has a method of obtaining a production efficiency percentage by applying all known local conditions and variables . . . plus a method of obtaining a complete direct labor rate for the craft or crafts involved in the various operations.

Subject areas covered include: shop fabrication of pipe and fittings, field fabrication and erection, alloy and non-ferrous fabrication, underground piping, hangers and supports, painting, patent scaffolding, insulation. To enable the reader to get more from the manual, there is a comprehensive sample estimate which may be used as a guide. Also, there is a section devoted to technical information which will be of benefit to the reader when preparing an estimate.

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Books . . .

and organizing for overseas engineering operations. In more general terms, the book describes how to develop research objectives, and how to make scientific research more managable. Other papers show how scientific manpower shortage can be relieved by accelerated and improved engineering education. This report is based on material from a recent AMA Engineering Management Form, and a special conference of the Association's Research and Development Division.

(AMA, *The Management of Scientific Manpower, (Report 22)*, American Management Association, 1515 Broadway, New York 36, N.Y., 160 pages, $3.75, or $2.50 for members.)

Where Are the Plants?

"Location of Manufacturing Plants by Industry, County, and Employment Size —1954 (Part 5)" answers the big questions: Where are the chemical, petroleum, and rubber plants? and how big are they? This joint publication of the Office of Area Development and Bureau of the Census, provides accurate data on plant locations and 1954 employment, from which useful patterns of distribution can be built.

(Bureau of the Census, *Location of Manufacturing Plants by Industry, County, and Employment Size—1954 (Part 5)*, Superintendent of Documents, Government Printing Office, Washington 25, D. C., 92 pages, 60 cents.)

Computer Symposium

"Proceedings of Joint NYU-IBM Symposium on Digital Computing in Chemical and Petrochemical Industries" covers a symposium held by New York University and International Business Machines Corp. in May, 1958. Topics discussed under Petroleum, Products and Programming include The Engineer, the Computer and the General Purpose Program; The Use of Linear Programming Techniques in Crude Oil Production, and Product Allocation by Linear Programming.

(Herbach, L. H., Editor, *Proceedings of Joint NYU-IBM Symposium on Digital Computing in Chemical and Petrochemical Industries*, New York University College of Engineering, Research Division, 401 W. 205th St., New York 34, N. Y., 189 pages, $7.)

ASA Measurement Tables

"Petroleum Measurement Tables, American Standard Z11.83-1956 (ISO Recommendation 91) have been published. The tables have been a joint standard of ASTM (D-1250) and the Institute of Petroleum, London, (IP 200) since 1952. The tables had been approved by ASA upon recommendation of its committee Z11, which is sponsored by ASTM. As a result of joint recognition by American and British petroleum industries, these two nations need not modify their measurement procedures for international trade purposes. The standards are not mandatory, but member nations are encouraged to use them as a basis for their own national standards.

(ASA, *Petroleum Measurement Tables, American Standard* Z11.83-1956, American Standards Association, 70 E. 45th St., Dept. PR 80, New York 17, N.Y., American Edition, $8.75; British Edition, $7 and Metric Edition, $7.70.)

Hydrocarbon Equations

"Equations of State for Hydrocarbons" contains a review of the development of equations of state and is accompanied by a discussion of notable achievements which have occurred during recent years in the prediction of volumetric behavior. This is the third volume in a series emanating from API Research Project 37 at the California Institute of Technology.

(API, *Equations of State for Hydrocarbons*, American Petroleum Institute, 50 West 50th St., New York 20, N.Y., 183 pages, $13, or $7.80 for API members.)

Refinery Waste Volume

"Manual on Disposal of Refinery Wastes, Volume I, Waste Water Containing Oil," has been published. This sixth edition, latest in the series, describes refinery operations which may result in the escape of oil into waste water; typical methods and devices used to remove oil from waste water; and recommended good practice for handling waste water and removing oil. Volume I contains much new material on chemical treatment, air flotation, secondary settling

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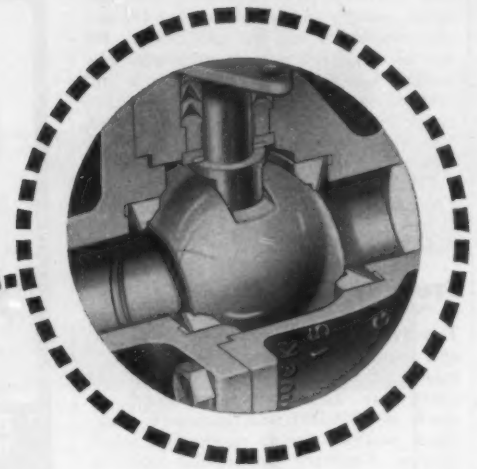
Ethyl Alcohol
Ethyl Sulfate
Ethylene Glycol Monobutyl Ether; Cellosolve
Fatty Acids
Foamite Solution Alkaline
Fruit Juices
Fuel Oil
Gases, Fuel
Gases, Hydrocarbon
Gases, Inert
Gases, Refrigerant
Gasoline Refined
Glaubers Salt
Glucose
Glycerine; Glycerol
Grain Alcohols
Helium
Hydrogen
Kerosene
Linseed Oil
Lubricating Oil
Magnesium Sulfate
Methane
Methanol
Mineral Oil
Mine Waters
Molasses
Neon
Oxygen
Pentane
Petroleum Oil
Potassium Sulfate
Printing Inks
Producer Gas
Propane
Propyl Alcohol
Return Condensate
Salt
Salt Cake
Salt Water; Sea Water
Sewage
Shellac
Sodium Sulfate
Sodium Carbonate
Soja (Soy) Bean Oil
Sweet Water
Tannery Liquors
Titanium Chloride
Vegetable Oils
Water
Water Glass

For more data on advertised products, use Readers' Service Cards, last page.

Toughest Ball Valve!



"Spring Pressure Compensated"

Here's the new 316 stainless steel ball valve that not only gives you maximum corrosion resistance, but also *positive* assurance of leakproof service!

It's Tightest because exclusive spring rings back up its double Teflon* seats . . . *automatically* compensate for pressure variations, wear, cold-flow deformation and temperature effects. With flow in either direction . . . under vacuum or 600 psi . . . seats always hug the ball. Low-pressure leaks just can't occur!

It's Toughest because it's the only ball valve with integrally cast flanges or screw ends. They *stay* leakproof even under constant vibration.

The new double seated stainless steel valve also gives you all the famous features of other Rockwood Ball Valves: smooth, full round flow; easy ¼ turn opening and closing; dead tight sealing without lubrication; and many more.

For use at temperatures from −65°F to +350°F, it can be easily modified for cryogenics applications. Just as ideal for vacuum service too . . . holds tight after long, continuous service. Send coupon for details on today's most versatile corrosion-resistant ball valve.

4 MODELS AVAILABLE- (Sizes ⅜″ through 2″)

- 600 psi with screwed ends
- 150 lb. flanged to M.S.S. with standard 150 lb. face to face dimensions. Also available with 150 A.S.A.
- 300 lb. flanged to A.S.A. with standard 300 lb. face to face dimensions.

*DuPont Reg. Teflon seals include seats and adjustable chevron stem packing. Also available with nylon or synthetic rubber seals.

ROCKWOOD BALL VALVES

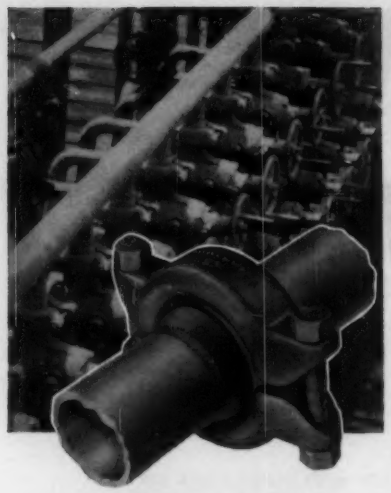
FULL, ROUND FLOW

ROCKWOOD SPRINKLER COMPANY
A Division of the Gamewell Company
222 Harlow Street, Worcester 5, Massachusetts

Please send full details on the new Type 316 Double Seated Stainless Steel Ball Valve.

Name.....*Title*.....
Company.....
City.....*Zone*....*State*.....
.....

For more data on advertised products, use Readers' Service Cards, last page.



GRAYLOC
Pipe Connections Make-Up In 3 Minutes

Unlike the 3-minute egg or the 3-minute car wash, GRAYLOC 4-inch Pipe Connections actually can be made up in 3 minutes by an unskilled laborer. What's more, the connection will test up to 10,000 p.s.i. every time. Two men can make-up a 24-inch connection in 15 minutes.

GRAYLOC, with its new principle in pipe make-up, can be broken out and re-made repeatedly with no wear or other damage to the connections and without replacement of the seal ring.

The GRAYLOC principle features flexible tapered lips of the seal which are angled slightly less than the mating hub. This forms a line seal which is changed to a surface seal as the connection comes together and the lips deflect. This design makes it possible for GRAYLOC to withstand full vacuum, high external pressure or extreme internal pressure.

GRAYLOC has practical applications in missile, chemical, petroleum, and atomic energy processes.

For additional information, write, wire or telephone Gray Tool Company.

GRAY *Tool Company*

P. O. BOX 2291 HOUSTON, TEXAS
REpublic 4-1641 3905

Books . . .

and ponding, vapor recovery devices for separators, and radioactive tracer technique for flow measurement.

(API, *Manual on Disposal of Refinery Wastes, Volume I, Waste Water Containing Oil,* American Petroleum Institute, 50 West 50th St., New York 20, N.Y., 92 pages, $2.)

The Age of Illumination

"The Age of Illumination" is a vivid panorama of the oil industry's early years, 1859-99. This definitive centennial history presents the facts and fables, people and problems, defeats and victories which laid the groundwork for the oil industry's present greatness. The book is based on years of research into original sources, many of which have never been in print. It contains about 150 illustrations of men and events in oil's early years.

(Williamson, H. F., and Daum, A. R., *The Age of Illumination,* American Petroleum Institute, 50 W. 50th St., New York 20, N.Y., $3.75.)

Prevent Water-Tower Fires

"NFPA Standard on Water-Cooling Towers" (No. 214) has been developed and published because of a series of major fires in cooling towers, some of which are large structures worth as much as $250,000 with extremely large losses possible due to production interruption. Contrary to popular opinion, these towers do burn. While the hazard is obviously greater when towers are out of service, many fires have occurred when towers were in use.

The standard, purely advisory as far as the NFPA is concerned, will make a useful guide for building inspectors, plant protection people and others who have to deal with this problem, and who have had no nationally-accepted guide to follow.

(NFPA, *Standard on Water-Cooling Towers (No. 214),* National Fire Protection Association, 60 Batterymarch St., Boston 10, Mass., 40 cents.)

Volitility of Gasoline

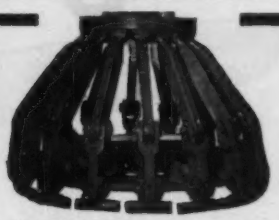
"A Study of the Basic Volitility Characteristics of Gasoline—Vapor Locking Tendencies—Test Methods, PB 151176," reveals that more reliable predictions of the vapor-locking tendencies of gasolines are possible through determination of vapor/liquid ratios of fuels at varying temperatures.

Measurement of vapor/liquid ratios of fuels gives values directly related to performance of vehicle fuel systems, reducing the chance of error in half. The report contains descriptions of the apparatus and tests, along with general and annotated bibliographies for vapor-lock literature.

(OTS, *A Study of the Basic Volitility Characteristics of Gasoline—Vapor Locking Tendencies—Test Methods, PB 151176,* Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., 85 pages, $2.25.)

Free Book Catalog

For a free copy of our book catalog write to BOOK DEPARTMENT, GULF PUBLISHING COMPANY, P. O. Box 2608, Houston 1, Texas. Often books reviewed here may be purchased from this source.



BARRETT automatic
Filling and Crimping Equipment
for handling greases and other viscous fluids.
- **No operator required.**
- **100% air operated.**

Fills, seals, stamps and counts lug cover pails. Output of 15 pails per minute. Write for details on installation to meet your requirements.

BARRETT
Manufacturing Co.
P. O. Box 8096, Houston 4, Texas

REFRACTORY HAYDITE
Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite. We sell direct to you.

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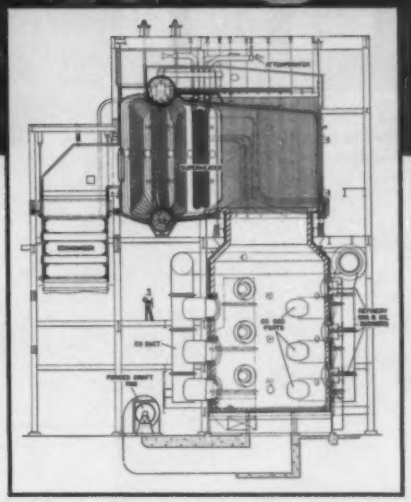
ABILITY

SACHSE ELECTRIC INC.
BATON ROUGE LA.

New Delaware Refinery, representing the advanced thinking of refinery engineers and technologists, can process 130,000 barrels of crude oil daily to manufacture products of unprecedented purity and power.

B&W CO Boiler Turns Waste Into Profit for Tidewater Oil Company

Gives 2-Way Bonus: Fuel Saving Sufficient To Drive Entire Cracking Unit *Plus* Help in Eliminating Air Pollution.



B&W CO Boiler is designed to generate 425,000 lb of steam at 600 lb pressure and 750 F degrees at the superheater outlet, utilizes 552,000 lb per hour of coker exhaust gases entering the boiler at a temperature of 1125 F degrees.

The Tidewater Oil Company, at its ultra-modern 130,000 barrel-per-day Delaware Refinery, installed a B&W Carbon Monoxide Boiler that is the largest of its kind in operation anywhere in the world. The exhaust gases from the fluid coker are recovered and used by the CO boiler to produce high pressure, high temperature steam for power and process requirements. The savings made possible by efficiently burning these gases which would otherwise be wasted, are expected to pay for the boiler within 3 to 4 years.

In addition to fuel savings, B&W CO Boilers also contribute to better community relations by helping to eliminate pollutants released to the atmosphere. This is accomplished by burning out the entrained coke dust and other combustible products discharged from the fluid coker.

For efficient and economical application in new or existing fluid coking and catalytic cracking units, B&W CO Boilers warrant careful consideration. For further information, write for Bulletin G-87, The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

B&W

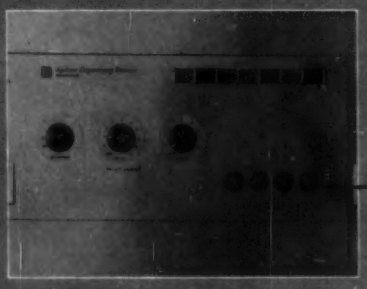
THE BABCOCK & WILCOX COMPANY

BOILER DIVISION

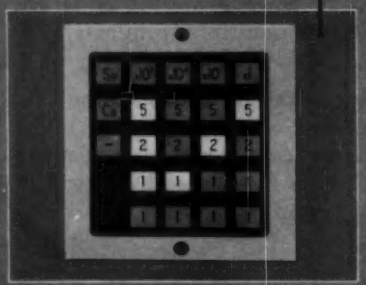
CO-100

New packaged Ho

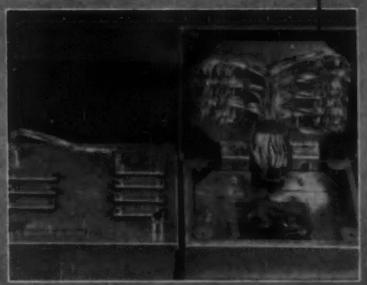
THREE 40-POINT ANNUNCIATORS make it easy for the operator to tell at a glance which variables are off-normal.



DIGITAL VISUAL DISPLAY and variable selector switches make it easy to select any single variable and watch all trends and changes continuously.



SERVICING IS SIMPLIFIED by an indicator-light panel showing the completion of each step in the analog to digital conversion. The sequence programmer can be changed from automatic to hand advance to permit operator to check each step.



UNIQUE INPUT SELECTOR is unusually dependable because of its sealed, oil-immersed construction. Servicing is normally limited to visual inspection every 6 months. Drawers pull out so voltage checks can be performed without shutting down system.

PINBOARD PROGRAMMING adds flexibility. You can change the logging or scanning sequence at will . . . substitute one type of input for another. Range, span, and zero adjustment are set by inserting pins in their proper places. No calculations are required. The pinboards are pinned in familiar units of measurements.

Honeywell logger-scanner

...accurate within ± 0.1% of reading

...pinboard programming for maximum flexibility

Here's a standard, all-purpose 120-point logger-scanner system with features formerly found only in more expensive, custom-designed equipment . . . the first of several packaged logger-scanners being introduced by Honeywell. It offers the ultimate in accuracy, flexibility, dependability and simplicity of maintenance. Wide ambient temperature operating limits—60 to 120°F—eliminate the need for special air conditioning equipment.

The Series 3120 accepts signals from primary measuring instruments—thermocouples, flow, pressure or other transducers. It measures these signals, digitizes them, and prints their values in immediately usable form. A thermocouple reference oven can be supplied to accommodate three types of thermocouple inputs—types T, J, and K—which are automatically linearized over their entire range to within 0.1% accuracy.

The operator can select either automatically or manually initiated logging cycles. He can set the system to log all variables automatically at preset intervals, or manually energize the system to operate on demand, between logging cycles.

Between logging cycles, the system can scan off-normal alarm points—high, low or both—at a rate of 7 points per second. Upon detecting an off-normal point, the system sounds an alarm, lights a point-identification light, and prints the time, point number and off-normal value on adding machine tape. During log cycles, off-normal points are printed in red on the log sheet.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

Honeywell

H HONEYWELL *First in Control*

TWO TYPEWRITERS permit a single line log allowing columnar comparisons. Separate alarm printer records all off-normal variables.

STANDARD MODULAR COMPONENTS are assembled on chassis mounted as individual drawers in relay racks. All drawers are connected by plugs for easy servicing.

New Equipment & Literature...

Phillips Licenses New Computer Controller

A reflux computer controller for improving efficiency of fractionating towers and other distillation facilities is currently being manufactured and marketed on license from Phillips Petroleum Co.

The device, using standard electric and pneumatic instrument components, is said to be the most efficient means yet devised for determining and controlling internal reflux flow rate. It is being sold under the trade name "FRAC" (Fractionator Reflux Analog Computer).

The Phillips technique measures external reflux flow and the temperature differential between tower top temperature and external reflux temperature to calculate the internal reflux flow. This value is then used as a signal for control purposes.

The new type of control provides faster corrections for variations in reflux temperature originating in condensing systems without additional equipment other than normal column instrumentation.

These other advantages, resulting in substantial savings, were listed for the fractionator computer:

- Less reboiler heat requirements.
- Reduction in off-specification product, eliminating reruns.
- Faster on-stream time.
- Continuous column operation nearer to flood point.
- Lower equipment and maintenance costs due to elimination of condenser temperature controls.

The fractionator reflux analog computer is a panel-mounted unit suitable for flush or surface installation. It contains a 0-15 psi test gauge on a four-position selector switch so that a check can be made on all pneumatic signals. It is completely piped internally, requiring only connections to the dry instrument air supply, the line from the external reflux differential pressure transmitter, and the line to the internal reflux flow controller.

Two variations are available. One is with a fixed range thermocouple-to-pressure transmitter, the other an adjustable range thermocouple-to-pressure transmitter to provide maximum flexibility for all applications. Brown Instrument Div. of Minneapolis-Honeywell Regulator Co.

Circle E1 green card, last page

Foam Is Newest Idea in Chemical Cleaning

A unique apparatus for making chemical lather or foam has been developed. The foam solvent is pumped from this apparatus directly into the tank, pipe or tower to be cleaned. When the vessel, or tank, is filled with the chemical foam, the process continues with the foam passing into a foam breaker and a filter which removes the material dislodged by the movement of the foam through the equipment. The solvent is then recycled through the foam generator and the unit being cleaned. Routine tests tell when the job is finished.

It is now possible to use chemical solvents to clean large volume systems with a relatively small amount of liquid, because the ratio of foam to solvent will average 20 to 1.

It will now be possible to chemically clean towers, pipe assemblies and other equipment that would not stand the weight and hydrostatic pressure caused if liquids were used. The low density or light weight of the foam eliminates this old cleaning problem.

It is now possible to use concentrated chemical solvents where needed. In many cases, the cost of concentrated liquid solvent was prohibitive due to the large volumes required.

The new foam technique makes it possible to remove readily any sloughed materials because of the excellent particle-carrying property of the foam.

Waste disposal problems following the use of the solvent foam method are reduced substantially because a smaller quantity of solvent will be used.

Complex equipment found in many industrial plants can be cleaned efficiently with the new method because the foam solvent fills completely every loop and bend, every nook and cranny.

The transportation costs will be reduced substantially when the new foam technique is used because smaller volumes of solvent will be required. Foam generating equipment is lightweight and can be moved to the plant site on a small truck.

A foam solvent for nearly every type of deposit can be tailor-made because research has disclosed a large numbers of chemicals and solvents, as well as foam producing chemicals.

The density of the foam must be regulated carefully in order to perform satisfactorily. An important feature of the new industrial chemical service is the ability to do this. The desired foam density is maintained by an instrument called a densitometer. This instrument monitors and records the foam density continuously.

It is now possible to eliminate after-rusting problems because the cleaned metal surfaces are not exposed to air during the cleaning process. The foam solvent is displaced directly with a foam rinse or flush followed by a foam passivator. Dowell Div., The Dow Chemical Co.

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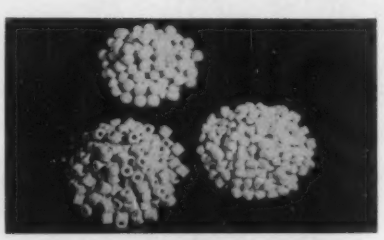
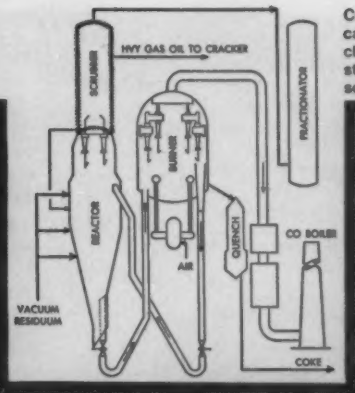


Catalyst Improves Precious Metal Recovery

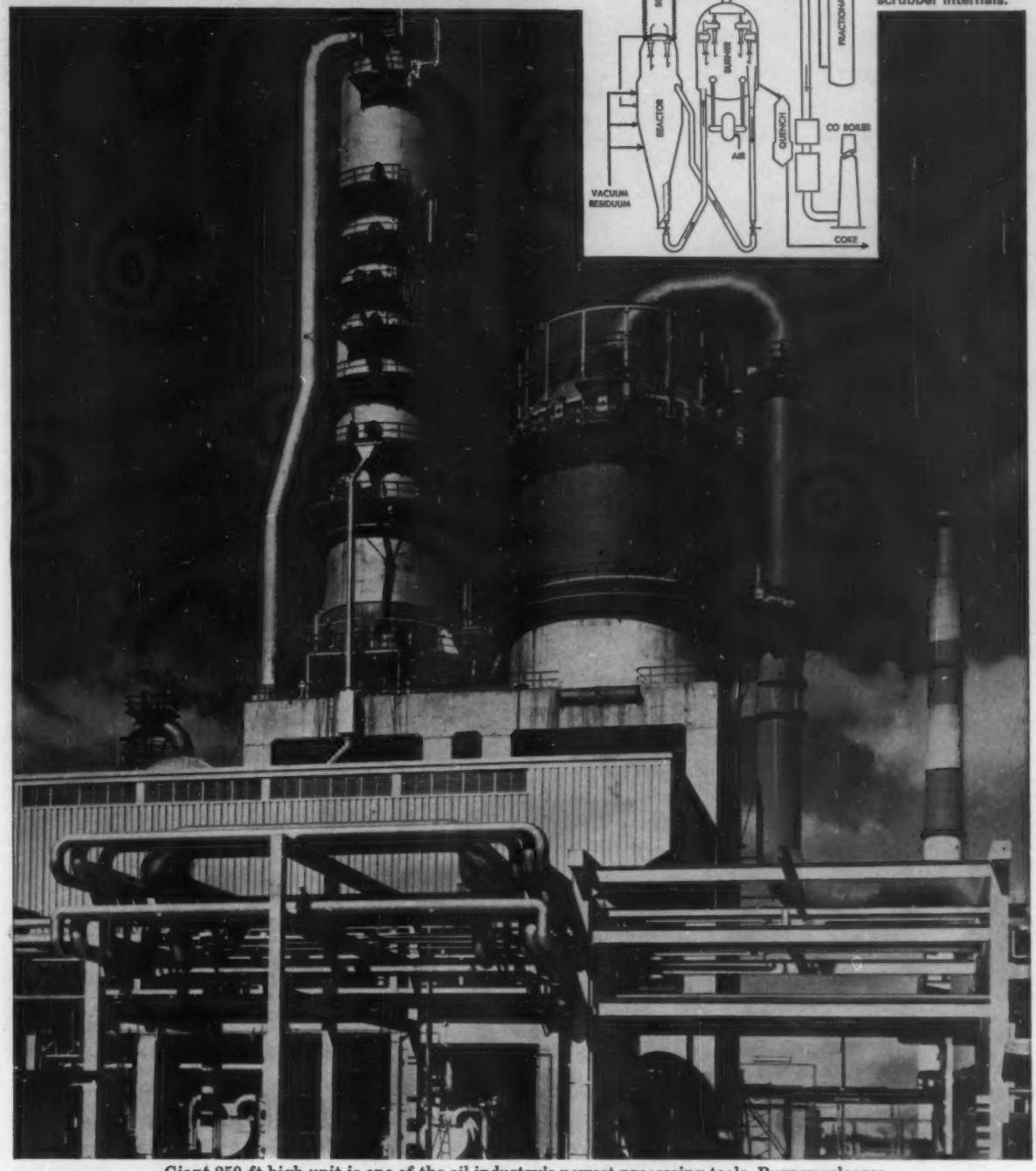
A new alpha alumina catalyst carrier, improving recovery of precious metal catalysts such as platinum, and a zirconia carrier capable of surface areas up to 70M2/g have been developed.

The newest alpha alumina product

Tidewater Fluid Coker continuously cracks 42,000 bpsd of vacuum tower bottoms



Cross-hatching indicates 18-8 stainless-clad steel. Solid 18-8 stainless is used for scrubber internals.



Giant 250-ft high unit is one of the oil industry's newest processing tools. Burner releases 400 million BTU per hour. This heat is transferred to the reactor through coke circulation.

18-8 Stainless Steel protects giant coker

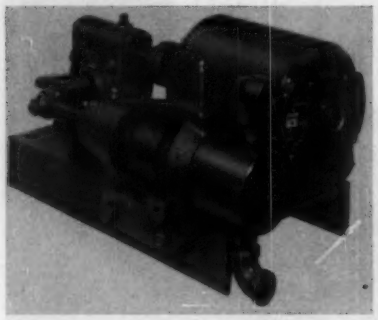
Diagram shows where Nickel-containing stainless steel combats corrosion in this unit. The principal corrosive is hydrogen sulfide in both liquid and vapor phases. Temperatures go up to 800°F. To keep your equipment on stream longer consider chromium-nickel stainless steels wherever conditions like this exist.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO NICKEL
NICKEL MAKES ALLOYS PERFORM BETTER LONGER

has a thin porous outer shell surrounding the core. Its expected improvement in precious metal catalyst recovery is based on regulating the size of the core, thereby controlling catalyst penetration. The new zirconia carrier is the most recent of improvements in carrier efficiency by varying surface texture. The Norton Co.

Circle E3 green card, last page



Metering Pump Designed For Chemical Processes

For metering clear and corrosive liquids to chemical processes, the dynamic new Model CM chemical metering controlled volume pump is offered.

This rugged, highly economical unit is job-engineered for metering situations requiring low-cost durability with top-notch accuracy.

Extensively tested in the laboratory and field, the pump delivers maximum capacities to 28 gph in simplex designs, and 56 gph in duplex designs (two liquid ends with a common motor and base). This hardy pump is quality constructed to handle pressures to 1,100 psi.

Screwed gland packing provides application flexibility and a choice of construction materials.

The pump features simplified construction for ease of operation and maintenance. Plungers are interchangeable within the pump frame, and models are easily converted in the field from simplex to duplex capacity. Cartridge-type column valves, with double ball checks identical on both suction and discharge ports, are replaceable at low-cost. Milton Roy Co.

Circle E4 green card, last page

Sulfur Recovery System Described in Booklet

Economical recovery of sulfur from hydrogen sulfide, and simultaneous alleviation of air pollution problems, are described in a new booklet, "Sulfur Recovery."

Process information, yields and utility requirements are included, together with a flow sheet and photographs of typical plants for recovery of sulfur from hydrogen sulfide removed during purification steps in natural gas and refinery operations. Girdler Const. Div. Chemetron Corp.

Circle E5 green card, last page

Find Tank Volume Quickly With Free Calculator

A handy, simple to use, tank capacity calculator that enables you to tell in a moment the volume contained in a vertical vessel is available for the asking.

This Solar Chicago tank capacity calculator is an invaluable aid in determining volume in gallons and barrels of vessels ranging in height from 5 to 100 feet. Solar Chicago, Div. of U. S. Industries, Inc.

Circle E6 green card, last page

Gasoline Dye Eliminates Storage Dusting Problems

A new granulated-oil red dye that eliminates dusting problems in storage and handling has been developed for use by refiners who color gasoline.

Known as Calcogas Rocket Red, this new dye is non-dusting, non-caking and very soluble. Its granular form facilitates its use in automatic metering and mixing equipment. Because of its non-caking properties, Calcogas Rocket Red resists change of physical state even at the elevated temperatures often found in refinery storage areas. American Cyanamid Co.

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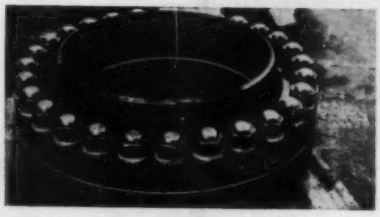


Pre-Assembled Insulating Flanges Cut Field Work

Availability of pre-assembled insulated flange joints in all pipe line sizes has just been announced.

Assembly in the shop avoids difficulties in field assembly of insulated flanges used to check electrolytic corrosion in underground piping, says the company. In addition it makes possible such extras as certification for maximum operating pressure and guarantee of zero electrical conductivity.

Dielectric (non-conducting) insulating gaskets, sleeves and washers eliminate any metal-to-metal contact that would permit flow of either induced or self-generated electric current.

In many instances, especially in 24 to 42 inch sizes, cost savings of 20 to 25 percent over American Standards flanges are feasible with insulated joints specially designed, manufactured and preassembled for particular service conditions, according to ASA principles. Tube Turns, Inc.

Circle E8 green card, last page

Hydraulic Packing Data Contained In Brochure

Sixteen pages of important engineering data are contained in a new brochure on homogeneous and fabric-reinforced hydraulic packings. The information encompasses design, construction, sizes, applications, installation, proper usage and service and temperature factors for V-rings, U-cups and piston cups. A 1-page insert on homogeneous wiper rings is also available. The text has with it illustrations, engineering drawings and informative tables. Crane Packing Co.

Circle E9 green card, last page

New Chemicals Make Water Asphalt Emulsions Stable

A long step toward a better and more convenient asphalt emulsion has been taken with the development of aliphatic organic chemicals which permit the preparation of stable cationic water-asphalt emulsions.

Cationic asphalt in the beaker on the right exhibits tenacious bond after immersion in water, while anionic asphalt strips off, as indicated by turbid water.

Traditionally, the anionic emulsions have been made with soaps or clays for emulsifiers. Minute globules of asphalt are suspended in a continuous water phase. When enough of this water is lost through evaporation or absorption, the emulsion becomes unstable and "breaks," depositing a film of asphalt on the desired surface.

Use of a small amount of the water-soluble hydrochloric or acetic-acid salts of a fatty diamine (trade-marked Duomeen), an ethoxylated Duomeen (the Ethoduomeens) or a quaternary ammonium compound (registered as Arquads) will minimize such problems. This is because cationic asphalt emulsions function by a different mechanism.

The cationic surfactants not only emulsify the water and asphalt, but are strongly attracted to any negatively-charged surface. Armour Chemical Div.

Circle E10 green card, last page

Couplings And Fittings Join Grooved-End Pipe

The introduction of a complete new line of couplings and fittings for joining grooved-end pipe has just been announced. Designated the Dresser Style-98, "Kupl+Lok", this new line presently includes couplings, ells, tees, reducers and line caps.

Style-98's are available in two complete series, the 98-1 for working pressures up to 500 psi, and the 98-2 for working pressures to 1,000 psi. Both series are available with either Dresser Grade-

INTEGRATED MANUFACTURING guides Goulds pumps through the foundry, machine shop and assembly plant to you.

Result? You get a pump that's made to order for the job it must do.

Manufacturing pumps "from foundry to finish" also cuts costs. That's why you get a *better* pump from Goulds—made from high-quality, precision parts—at no greater cost than other pumps.

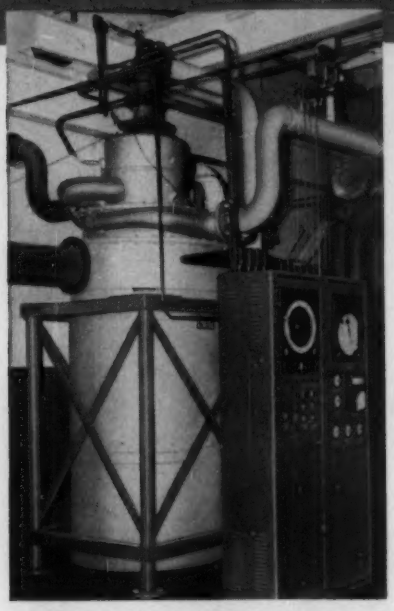
And, because it's not a mere assembly job, a Goulds pump can be designed and built for interchangeability —to cut your spare parts inventory and maintenance costs.

To completely control the production of our designs, we had to build the world's largest plant devoted to the manufacture of pumps exclusively. Over 100 years of experience gives us the know-how.

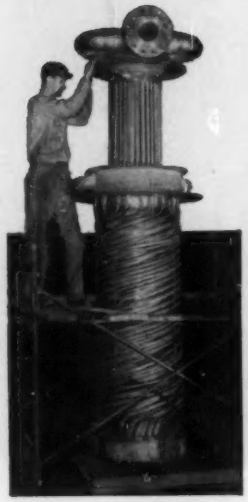
For help in solving *your* pumping problem, write to Goulds Pumps, Inc., Dept. PR-89, Seneca Falls, N.Y.

GOULDS GP PUMPS

THERMAL
FIRED
HEAT EXCHANGERS



a compact means of heating air or process gases for testing or production



THERMAL HIGH VELOCITY BURNERS MAKE THESE HEAT EXCHANGERS POSSIBLE...

Whether it be an existing standard design or a unit for special requirements, THERMAL heat exchangers provide the ultimate in compactness, high performance and response. These heat exchangers are always designed around the high velocity, clear flame combustion characteristics of THERMAL burners. Convection is thus the primary means of heat transfer thereby promoting uniform metal temperature and long life. THERMAL Heat Exchangers are supplied as complete package installations including all control and accessory equipment.

DESIGNS AVAILABLE FOR:

Pressures from 0 to 1500 PSIG. Temperatures from 300°F to 1500°F. Heat transfer ratings from 250,000 BTU/hr to 35,000,000 BTU/hr.

Other Thermal Products & Services

Gas, Oil & Combination Burners • Air Heaters • Submerged Combustion • Combustion & Heat Transfer Equipment

THERMAL

Thermal Research & Engineering Corp.

CONSHOHOCKEN • PENNSYLVANIA

REPRESENTATIVES IN PRINCIPAL CITIES

Equipment . . .

30 gaskets for general service or Dresser Grade-69 gaskets for oil and gasoline.

Style-98's are carefully engineered and constructed to meet exacting ASTM specifications. Bodies are of rugged malleable iron and are Dresser Red-D Shop-coated to provide corrosion protection. Bolts are oval-neck, track-type of heat-treated carbon steel to ASTM standards and are black with an oil finish.

Style-98's are speedily assembled simply by drawing up the two bolts which extend through the coupling halves. The special gaskets firmly grip the pipe ends, maintaining even pressure around the circumference of the pipe, to afford a leakproof, permanent seal. These resilient gaskets also enable piping to safely absorb pipeline stresses and movements. Dresser Mfg. Div.

Circle E11 green card, last page

3-Inch PVC Valve First Of Its Kind Available

The "only 3-inch polyvinyl chloride (PVC) Y-Globe valve, check valve and strainer manufactured" is available. This extension makes the company's PVC-Y-Globe valve line "the largest available." PVC valves which are highly recommended for low and medium pressures and temperatures (150 psi, at 72°F) have met with wide acceptance since their introduction a few years ago.

PVC's popularity is laid to several features that metal valves cannot offer—(1) Its light weight (actually 1/6 that of metal) cuts installation costs considerably, (2) high corrosion resistant properties make it particularly popular in the chemical and allied industries. Walworth Co.

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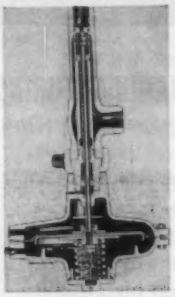
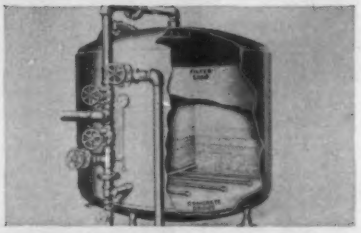
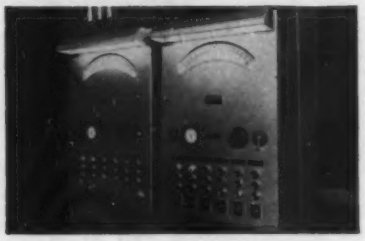
Control Valve Retards Freezing By Absorbing Heat



Newly developed is the Type 125 Anti-Freeze control valve for use as a liquid-dump valve on high-pressure oil and gas separators and other processing vessels. The elongated angle-style body, designed for vessel adaptation, retards freezing action by absorbing heat from the gases at the top of the vessel. It may be operated by instruments such as intermitters, pressure controllers and level controllers. The valve body is electric cast steel with a pressure rating of 3,000 psi WOG. It has 1-inch female NPT inlet and outlet connections and a 2-inch male NPT vessel coupling con-

You get dependable performance for all types of brine and water treatment with INFILCO equipment





ACCELATOR®
plants for clarification, softening and stabilization
Effective mixing of chemicals and raw water with recirculating slurry and downflow separation effect better treatment in minimum area — and at low cost. For water, brine or waste treatment.
BULLETIN 1825

CHEMICAL FEEDERS
Accurately controlled feed rates and maximum econon.y
Compact designs for automatic or manual control, for all types of chemicals. Type E Feeders dispense dry chemicals volumetrically, from bulk storage to dry or wet applications. BULLETIN 215

NEUSOL® FEEDERS
Wide feed range, corrosion resistant construction adapt this versatile and dependable displacement feeder to most chemical solution requirements.
BULLETIN 340

AERATORS and DEGASIFIERS
For all types of gas-liquid transfer applications. Efficient oxidation, carbon dioxide and hydrogen sulfide removal.
BULLETIN 106
Request information on recarbonators, deaerating heaters and vacuum degasifiers.

PRESSURE FILTERS
Standard or special construction for the most exacting process requirements
Vertical or horizontal, sand or anthracite types with manual or automatic controls for water or brine filtration. BULLETIN 1520
The STELLAR® diatomite filter, with its exclusive "gas-bump" cleaning is standard for amine solutions in most of the largest gas companies. BULLETIN 1560

MODERN INSTRUMENTATION
Maintains efficiency, reduces operating cost of treatment
Design and assembly of pneumatic, electric or hydraulic control components for manual or automatic, constant or variable rate plants. Operating consoles and control panels specifically engineered for complete treating plants. BULLETIN 1100

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Field offices throughout the United States and in foreign countries

57402

INFILCO CAN help you solve any water and brine treatment problem in oil production and refining

From experience, extending over 60 years, INFILCO can give you the best results with lowest *first* cost and *operating* costs.

No other line of equipment is so complete—none so advanced in method and design. Above are a few examples.

It will pay you to investigate. Inquiries are invited on all matters relating to water or brine treatment. Write today for new condensed catalog, Bulletin 80, for a more complete description of INFILCO products.

THE ONLY COMPANY impartially offering equipment for ALL types of water and waste processing—coagulation, precipitation, sedimentation, flotation, filtration, ion exchange and biological treatment.

nection. Fisher's standard "P" body stuffing box and bonnet nut and inner valve and cage assembly are incorporated into the "AF" body. This simple arrangement insures correct alignment, adequate strength and straight-forward assembly and disassembly. Fisher Governor Co.

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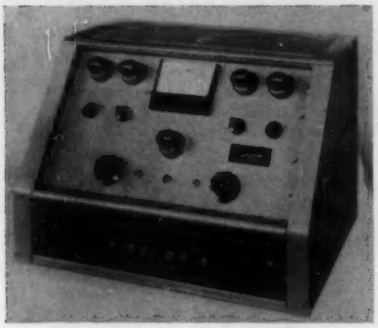

Computer Speeds Gas Chromatographic Analysis

An unusual contribution to gas chromatographic analysis is an analog computer just developed.

To aid the analyst and speed up his efficiency, as well as to insure accuracy, the Computagram now makes it possible to calculate a complete analysis in less than three minutes. Calculated percentages are accurate to within one percent. The computer corrects peak areas or peak heights for differences in the response of the detector, and normalizes the corrected areas or heights to total 100. This gives the percent (mole or weight according to correction factors inserted) of each individual component.

The computers are available in three models, differing only in the number of components which they can handle. The model illustrated in the photograph is designed for simple mixtures having four or less components, such as liquefied petroleum gases. Other models are designed to handle up to 8 or 12 components. Poddielniak Inc.

Circle E14 green card, last page

Brochure Covers Worldwide Construction Services

"The Plant You Want To Build" is the title of a new informative brochure. It is for selective distribution to engineers and executives in all process and manufacturing industries in addition to those in the chemical, petrochemical and petroleum refinery fields in which the company is already known. The 24-page institutional-type piece interestingly details the character and worldwide range of process engineering services now offered. Fast-reading and well illustrated, it lucidly describes how the company has integrated the facilities of its domestic and foreign subsidiaries to flexibly provide the optimum organization to design, or engineer, or erect whatever plant is desired. Foster Wheeler Corp.

Circle E15 green card, last page

Tried Phosphorus Additives In Your Gasoline Blending?

Developmental quantities of two new phosphorus-containing gasoline additives are available.

The two compounds, Ucar gasoline additive 4BP and Ucar gasoline additive 2CP, are slightly viscous, high-boiling liquids that are miscible with commercial gasoline and compatible with conventional additive and dye systems.

Ucar additive 4BP is tetrabutyl pyrophosphate which contains 15.39 weight percent phosphorus, and is recommended for use as a pre-ignition suppressor and spark-plug and anti-fouling additive. The other compound, Ucar additive 2CP, is chemically 2-(2-chloroethoxy)-5-ethyl-5-methyl-2-oxo 1,3,2-dioxaphosphorinane. It contains 12.77 weight percent phosphorus and 14.61 weight percent chlorine, and is recommended for use as a pre-ignition suppressor, spark-plug anti-fouling additive, and lead scavenging agent. Neither compound has adverse effects on the octane rating of commercial gasoline as measured in CFR (Cooperative Fuel Research) engine tests. Union Carbide Chemicals Co.

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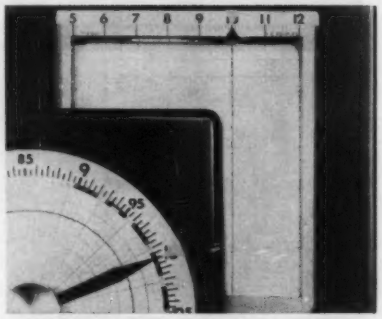

Space Saving Featured In Two Recording Controllers

Two new space-saving models of the Speedomax H Recording Controller for steam temperature control are now available.

Both models are only 12 inches high and 11 inches wide, yet offer easy readability. The Model S strip chart is best for detailed records with its 6½-inch linear scale. The Model R is recommended for bold indication; even slight deviations in temperature are easily seen from a distance. Curves are easily read since they are plotted along a straight-line radial scale.

With its range of 500 to 1200° F, the instrument has an accuracy of better than ± 0.3 percent, while sensitivity is better than ± 0.1 percent. Its control slidewires and adjustable alarm contacts are mounted on a rigid shaft for permanent alignment. Other safeguards include a factory-set high-alarm contact to lock out control and sound an alarm in the event of a severe disturbance, or a thermocouple or amplifier failure. Amplifier and thermocouple fail-safe circuits are also provided for added protection. Leeds & Northrup Co.

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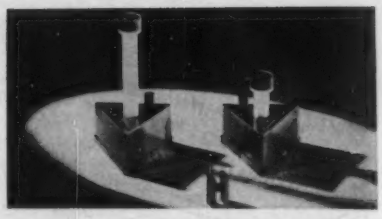

Recorder Pen Writes Three Weeks Without Cleaning

A new recorder pen, combining the best features of lettering pens with the reservoir principles of current recorder markers, has just been introduced. The new pen will start to write the instant its nib touches the writing surface, even after hours or days without use. Its design eliminates leaking or clogging, as well as the annoying omissions in recording due to pen skipping.

Two sizes are available: a small model for use with the "Infracord" infrared spectrophotometer; and a large model designed for other model spectrophotometers.

The pen's nib is hollow stainless steel with a stainless steel wire threaded through it. The nib leads back into a primary reservoir cap, which in turn is fed by a capillary tube extending down into the main ink reservoir. Twin vent holes in the pen's cap provide for atmospheric pressure to maintain flow in the capillary feed.

Tests with a standard brand of india ink have shown the new pen will write continuously for over three weeks without cleaning.

The entire one-piece unit is fabricated of polystyrene. It is supplied with instructions in a permanently useful plastic stand. Stands can be easily clipped together for convenience in storing pens containing different colored inks. Perkin-Elmer Corp.

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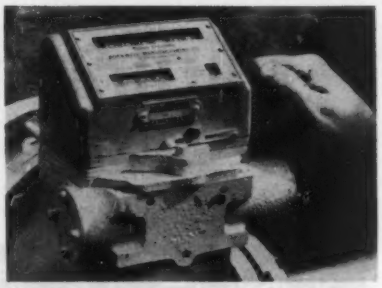


Flow Meter Reduces Connections Needed

A new petroleum and industrial Rotocycle meter, with a special in-line steel case that provides greater economy and adaptability has just been introduced.

Designated the 2S, the meter does not need a manifold or 45-degree elbows when used on horizontal piping lines. This cuts down the number of connections needed, makes the meter more compact and simplifies installation.

Design advantages are:

• Direct Rotary Flow. A steady re-

Bristol Dynamaster* Electronic Instruments have proved themselves in thousands of installations. They fully meet today's most exacting standards of accuracy and dependability. They measure almost any variable that can be translated into an electrical quantity (d-c current, d-c voltage, resistance or capacitance). Just a few are: temperature, pH, speed, voltage, smoke density and strain.

Here are some outstanding features that make them ideal for industrial plants, pilot plants, and for research, test, and laboratory use:

1. Continuous standardization—eliminates standardizing mechanism and dry cell—no interruption to control. **But retains precision standard cell for highest accuracy and stability.**

2. Simple design—few moving parts.

3. Easy to use and service—little or no maintenance required.

4. Rugged construction—unaffected by vibration.

MODELS FOR EVERY PURPOSE. Dynamaster Instruments are now available as:

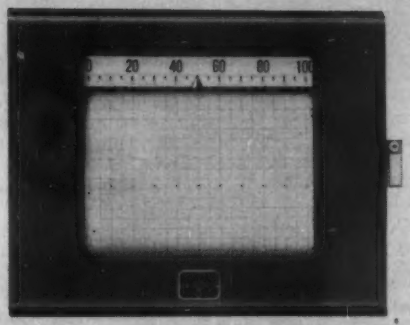
A. Single-pen, two-pen, and multiple-record (up to 24 points) strip-chart instruments.
B. One- and two-pen round-chart recorders.
C. High-speed recorders (0.4 second).
D. X-Y recorders.
E. Extended range recorders.
F. Adjustable span and zero recorders.
G. Miniature 3-inch strip-chart recorders.
H. Electric controllers in both strip- and round-chart models—all types of control action and as time-program control.
I. Pneumatic controllers in both strip- and round-chart models—all types of control action and time-program control.
J. Instruments for electronic measurement—pneumatic transmission of reading by 3-15 psi signal.
K. Round chart program controllers.
L. Telemetering transmitters.
M. Drum-type precision indicators.
N. Multi-bank recorder—will accept up to 200 separate inputs and record them on 12-inch wide strip chart.
O. Relay-rack mounting models—most models available in case that fits standard 19" relay-rack without modification to instrument or rack, without panel-cutting or masking.

Bristol Dynamaster Potentiometer and Bridge Instruments can be equipped with analog-to-digital encoders of various types for digital readout and computer use. For complete details, write for Bulletins P1245A, P1270, P1271, P1242, and P1282. The Bristol Company, 111 Bristol Road, Waterbury 20, Conn.

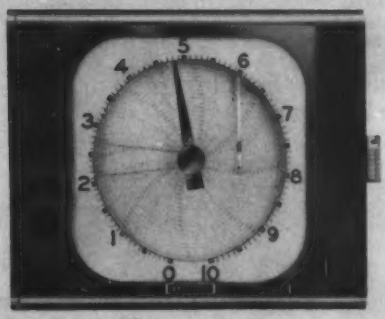
*T. M. Reg. U. S. Pat. Off.

look to Bristol for the complete line of

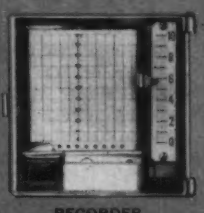
ELECTRONIC POTENTIOMETER and BRIDGE INSTRUMENTS



Dynamaster* Electronic Potentiometer or Bridge—records on 11-inch, 120-foot-long strip chart.



Dynamaster* Electronic Potentiometer or Bridge—records on 12-inch round chart, indicates on extra-large scale.



RECORDER

INDICATOR

Plug-in Miniature Electronic Dynamaster Potentiometer and Bridge Instruments—Only 5" x 5⅛" panel dimensions; ideal for graphic panel instrumentation.

BRISTOL

TRAIL-BLAZERS IN PROCESS AUTOMATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

volving ease of motion is present because the liquid moves through the Rotocycle in a direct rotary "Flow-Ward" path from inlet to outlet—there are no winding passages to obstruct flow.

• Liquid Capillary Seals. Minute clearances between the revolving measurement parts and the chamber wall create effective liquid capillary seals which eliminate costly, part wearing metal-to-metal contact.

• Low-Friction Construction and Minimum Flow Resistance. The measuring vanes and rotor assembly revolve on hard carbon low friction bearings which keeps friction to a minimum. The elimination of elbows means a minimum of flow resistance—power needs are reduced and further savings are made because smaller motors can be used to drive pumps.

Other outstanding features are a variable speed device; micro adjustment, which varies the speed ratio between the meter and the register; and a teflon-shaft seal which protects the register drive mechanism and register proper. The micro adjustment provides positive adjustment to allow for metering variations caused by changes in liquid properties and variables in the meter installation.

Weighing only 130 pounds (shipping weight, less register) the Type 2S accurately measures flow rates ranging from 20 to 100 gallons per minute. Working pressure is 300 psi with a series-30 flange and 215 psi with a series-15 flange. The meter is available with non-reset, small reset, large reset or printing register. Rockwell Mfg. Co.

Circle E19 green card, last page

Vapor Entrainment Problem Discussed In Brochure

Designed for engineers, operating executives and purchasing agents who need at their fingertips a complete catalog of purifiers, separators, mist extractors and scrubbers is the new 8-page Anderson Bulletin 803.

This brochure permits solution of a multitude of gas, air, steam and vapor entrainment problems by picturing and carefully describing the specification and operations of practically every item in the company's purifier line.

Thirteen Hi-eF Purifiers are cataloged in all, including line types for entrainment removal service in large pipelines, receiver types designed for extremely large slugs of liquid, high-pressure types capable of withstanding pressures up to 15,000 psi, exhaust heads for cleaning up exhaust gases and vapors discharged to atmosphere, internal types for evaporator and boiler service, and small-line types for keeping moisture and dirt from damaging expensive pneumatic and steam tools.

Guarantees, code information, typical installation drawings and other engineering data are given for each unit. The V. D. Anderson Co.

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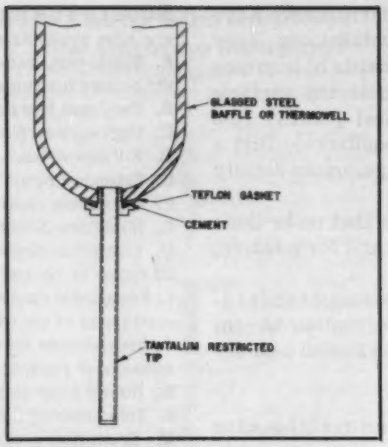

Thin Wall Tubing Cuts Tantalum Thermowell Costs

Availability of moderately priced tantalum-tipped thermowells as auxiliary equipment for use in glassed-steel process equipment has just been announced.

The new thermowells are very responsive to changes in "bath" temperatures because of tantalum's innate high heat transfer characteristics and because of the very thin wall sections that can be used. Tantalum also possesses excellent corrosion resistance and resistance to damage from either thermal or physical shock. Tantalum's corrosion resistance is comparable to that of glassed-steel with the exception of resistance to free SO_3.

Reduction in cost of tantalum-tipped thermowells has been made possible by the development of special welding techniques. In the past, it was necessary to machine the thermowells from bar stock with consequent material loss and high cost. Inert gas welding in a special chamber permits use of thin-wall tubing and limits bar stock to the amount required for the threaded end.

At the present time the company is fabricating tantalum-tipped thermowells with ⅜ and ½ inch I.D. with rated external pressures of 400 and 270 psi respectively. The Pfaudler Co.

Circle E21 green card, last page

Catalog Describes New Line of Pressure Gages

A four page catalog describing a recently introduced line of Solid-Front Pressure-Indicating and Test Gages has been published. These gages are housed in a rigid case with integrally cast front shield to protect personnel in the event of a blow-out. Over-pressure conditions are relieved by the full nylon blow-out back, a unique corrosion-proof, weatherproof feature of the company's Solid Front Gage.

The catalog describes in detail the 4½, 6 and 8½-inch diameter gages—both flush and surface mounted—which are now offered with the safety-back, solid-front construction. It also gives complete construction details with diagrams and photos. Crosby Valve & Gage Co.

Circle E22 green card, last page

52-Page Booklet Features Alkyl and Alkylene Amines

A new 52-page booklet, describing the properties and uses of alkyl and alkylene amines, has just been published.

The booklet contains comprehensive data for 19 amines, including physical properties, tables and charts, end-use possibilities, shipping data, constant boiling mixtures, specifications, and test methods, physiological properties, and storage and handling methods. A detailed bibliography and reference section is included.

The alkyl amines are intermediates for specialty soaps, dyestuffs, rubber chemicals, flotation agents, textile specialties, corrosion inhibitors, petroleum specialties, and pharmaceuticals.

The alkylene amines are intermediates for "wash and wear" textile finishing resins, fungicides, herbicides, corrosion inhibitors, petroleum additives, emulsion breakers, pharmaceuticals, polyamides, synthetic rubber activators, chelating agents, and epoxy resin curing agents. Union Carbide Chemicals Co.

Circle E23 green card, last page

Unit Designed For High Speed Gas Compression

A new line of high-speed, multi-stage, centrifugal compressors have been engineered for gas compression applications including fractionation, liquefaction, chemical reaction, storage and refrigeration. According to the company, the Turbomaster line provides the most rugged, reliable answer to high-speed gas compression ever offered to the petroleum and petrochemical industries. For example, this compressor has approximately 400 fewer parts than the conventional centrifugal compressor.

A flexible disc-type coupling is used which needs no lubrication and allows full access to compressor seals and bearings without moving the compressor or driver.

The Turbomaster line has an exclusive adjustable prerotation vane inlet control which allows the operation to adjust—by power cylinder or handwheel—the pressure or capacity of the unit without throttling losses. This prerotation vane control generally eliminates requirements for variable speed drives. York Corp.

Circle E24 green card, last page

PVC Fittings Offered In Three New Sizes

With the addition of three sizes (¼, ⅜ and 1¼ inches) to its rigid PVC (polyvinyl chloride) Y-globe valves, check valves and strainers, a manufacturer is in a position to offer these products in a complete range of sizes from ¼ to 2 inches. PVC products offer exceptional resistance to inorganic salts, alkalis, acids and other corrosive fluids. The Y-globe valves, check valves, and strainers operate successfully at pressures to 150 psi at 75F. The 3-inch size will be available soon. Walworth Co.

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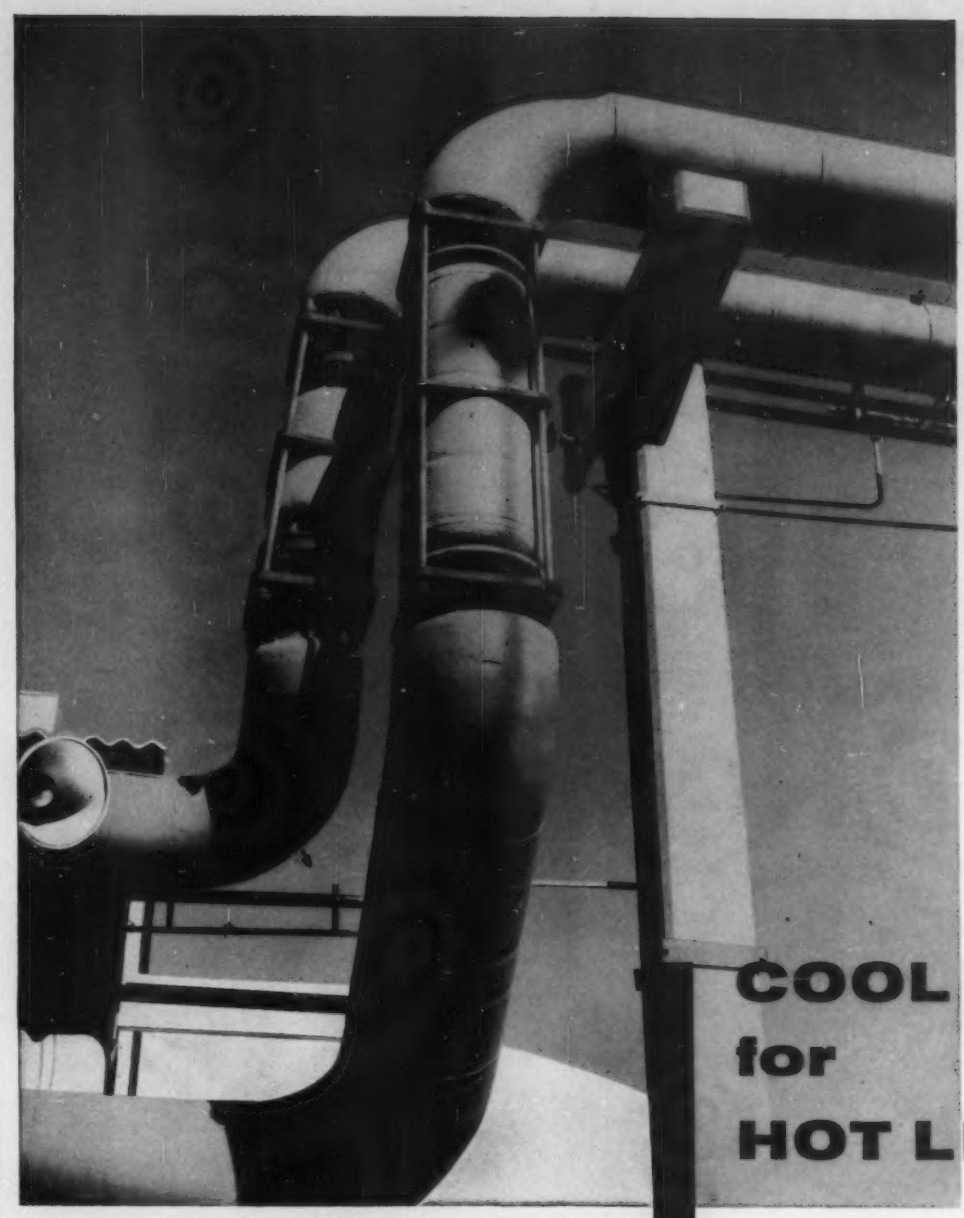

COOL IDEA for HOT LINES

ADSCO DIVISION

World's Oldest and Largest Manufacturer of Expansion Joints

20 MILBURN ST., BUFFALO 12, N. Y.

YUBA

Plants and Sales Offices

YUBA CONSOLIDATED INDUSTRIES, INC.

Adsco Corruflex Packless Expansion Joints, of course.

This unusual photograph illustrates the tremendous stresses which must be absorbed in process piping. Adsco Corruflex Expansion Joints are custom-engineered for your particular piping problems.

These joints with stainless steel bellows were designed and manufactured for Callery Chemical Co., Muskogee, Okla., as an integral part of Callery's high-energy fuel plant. Adsco also makes bellows of carbon steel, copper, Hastelloy, Inconel, Monel, nickel, aluminum, and many other metals.

Corruflex Expansion Joints are available in sizes 3" and larger, with sleeves, for temperatures from 400°F below zero to 1600°F and higher, and for pressures from full vacuum to 1000 psi and above. Write for Bulletin 59-50.

For more data on advertised products, use Readers' Service Cards, last page.

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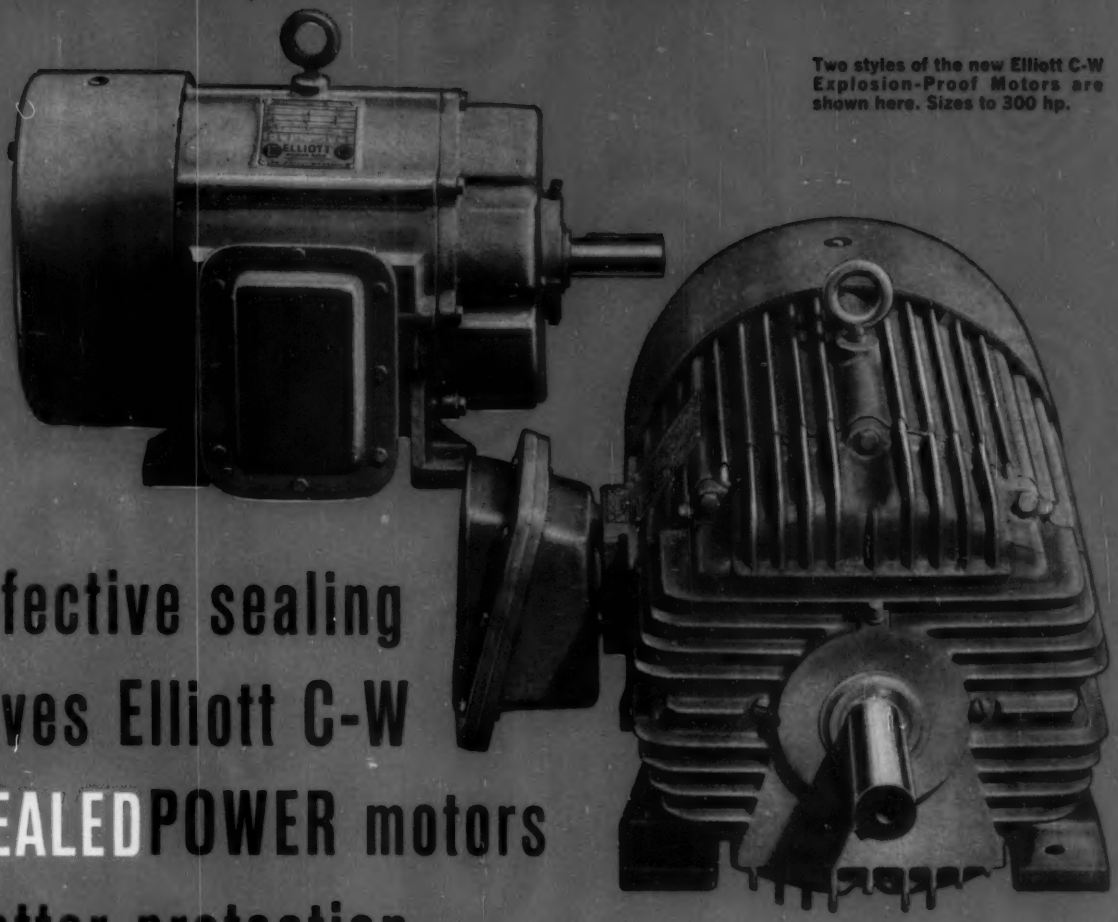

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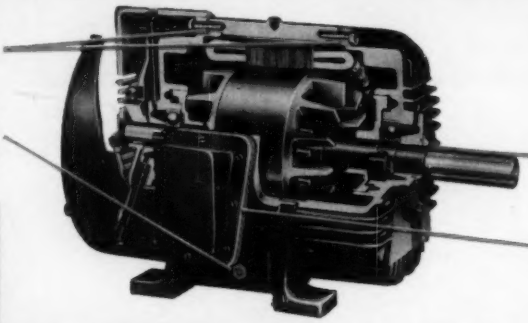

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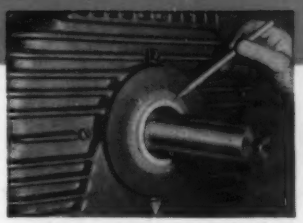

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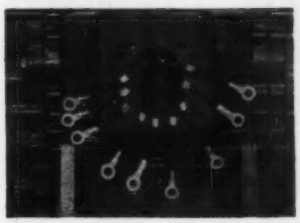

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